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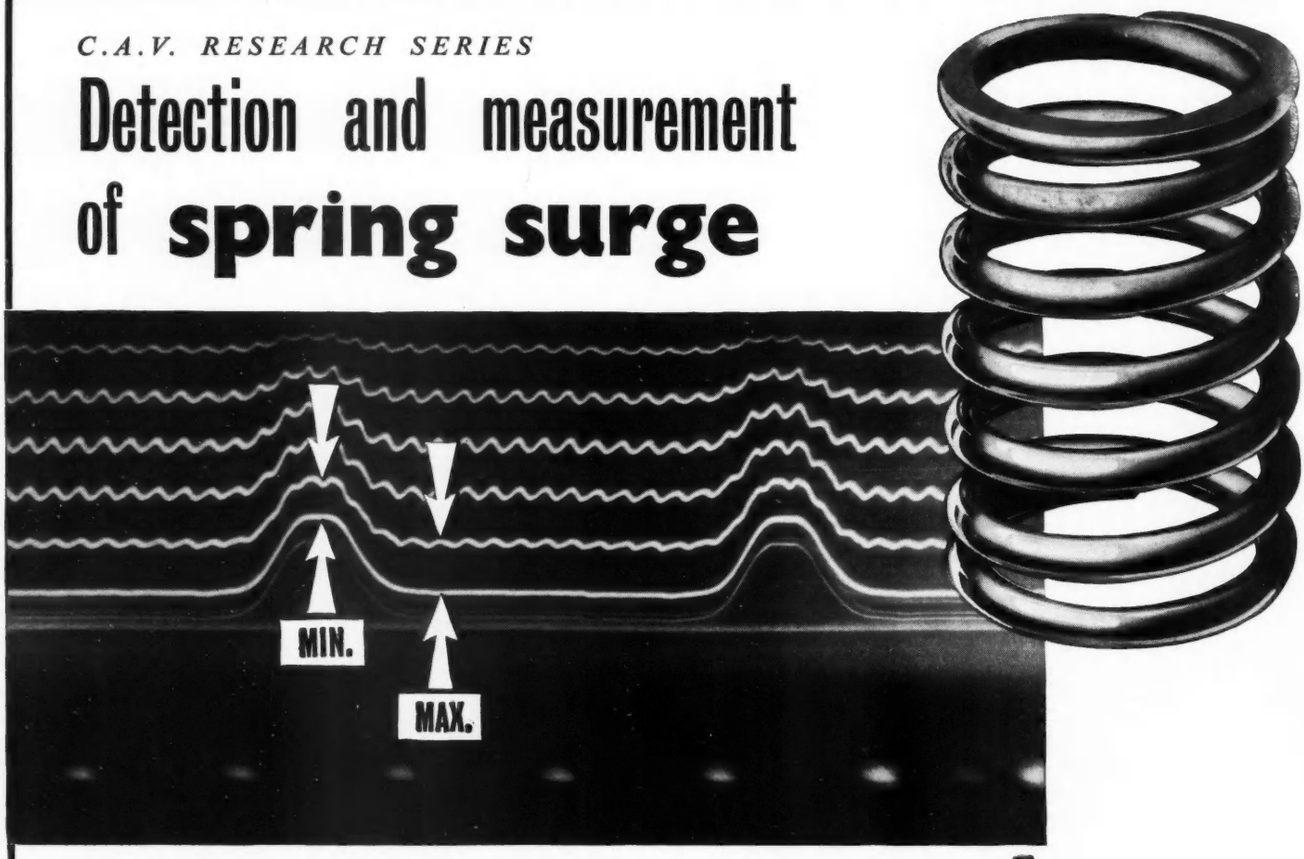
BEVERLEY MARK I TRANSPORT AIRCRAFT.

C.A.V. RESEARCH SERIES

Detection and measurement of **spring surge**

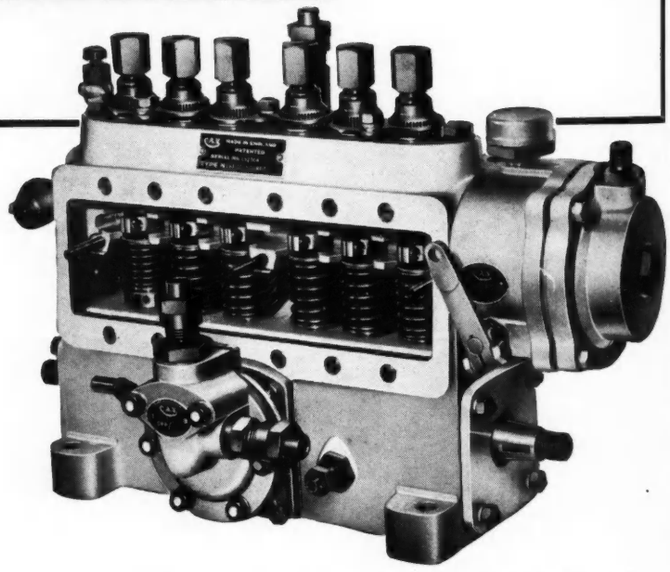


The firm line shows the cam rise over two cycles. The lower dotted trace shows time intervals of 10 milliseconds.

When a spring is abruptly compressed, its coils may be caused to "surge", that is, the centre coils are displaced relative to the ends to a greater extent than during the slow compression of the spring, and then vibrate.

Normally, the compression of the spring subjects the material to stresses which are well within its fatigue limit. When the spring surges, however, the oscillation of the coils is added to the normal movement. The stress-range to which the material is subjected is enhanced, and may become excessive.

The illustration above is from a research laboratory record of surge in a spring, the wavy lines showing the displacements of individual coils. The stress range in any turn can be deduced by observing the minimum and maximum turn-to-turn distance.



Surge is an ever-present hazard in coil springs which are compressed abruptly, such as tappet or injection pump plunger springs, and research of this type enables it to be guarded against in the design of equipment.

Research of this nature guarantees the high quality and performance of C.A.V. Products

C.A.V.

Fuel Injection and Electrical Equipment

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ENGINEERING, MARINE AND WELDING EXHIBITION AT OLYMPIA,

INCORPORATING THE CHEMICAL PLANT EXHIBITION.

(*Continued from page* 265.)

THE Engineering, Marine and Welding Exhibition —with a chemical-plant section this year—opened at Olympia, London, yesterday and will remain open from 10 a.m. to 8 p.m. daily, except Sundays, until the evening of Thursday, September 17. Some more exhibits are described in this, the second, article on the exhibition. An exhibit of exceptional interest, which has already been described in ENGINEERING, is the gas turbo-alternator set consisting of a Ruston and Hornsby gas-turbine coupled to a British Thomson-Houston 1,250-kVA alternator. This set can be seen running under load and supplying electricity to the exhibition halls.

250-B.H.P. "PACKAGED" POWER UNIT.

The exhibits of Crossley Brothers, Limited, Manchester, 11, are mainly their Diesel engines of the pulse-charged two-cycle type, better known as scavenge-pump Diesel engines. Apart from a display of working models, there are five full-size engines: a 1,380-b.h.p. power unit for Diesel-electric locomotives, an 800-b.h.p. general-purpose V-type Diesel engine, a 1,100-b.h.p. marine propulsion engine, a 250-b.h.p. packaged power unit, and a 670-b.h.p. marine propulsion engine. The two last-mentioned engines are shown in Figs. 41 and 42, below.

The 250-b.h.p. packaged power unit incorporates a four-cylinder scavenge-pump Diesel engine of the firm's "EST" type. It develops 250 b.h.p. at 900 r.p.m. and is supplied, as a packaged power unit, with a radiator, a baseplate and a clutch-operated power take-off. A large number of these units have been installed in excavators, but they are designed for a wide range of applications. The scavenge-pump type of Diesel engine, being simple in design and compact, is regarded as particularly suitable for applications where reliable and continuous performance, ease of maintenance and mobility are important.

670-B.H.P. MARINE PROPULSION ENGINE.

The engine shown in Fig. 42, designed for marine propulsion, has a continuous rating of 670 b.h.p. at 500 r.p.m., 570 b.h.p. at 400 r.p.m., 500 b.h.p. at 340 r.p.m., and 440 b.h.p. at 300 r.p.m. It is a six-cylinder scavenge-pump engine, representative of the firm's "HRN" range, which cover power requirements from 210 to 900 b.h.p. These engines are all of the two-cycle type, with port-controlled loop scavenge, exhaust-pulse pressure charging and direct reversing. The guaranteed fuel consumption is 0·360 lb. per brake horse-power per hour. Oil-cooled pistons are employed and a copious supply of lubricating oil is maintained by two gear pumps, one of which operates as the engine pump and the other as the lift pump, with an accessible external sump tank. A lightweight tandem reciprocating scavenge pump of high efficiency is built into the forward end of the engine. The makers state that these engines are reliable, economical and compact in overall dimensions and are suitable for slow or medium speeds in direct-coupled form. Alternatively, at higher engine speeds they are suitable for geared applications, again usually direct-reversing.

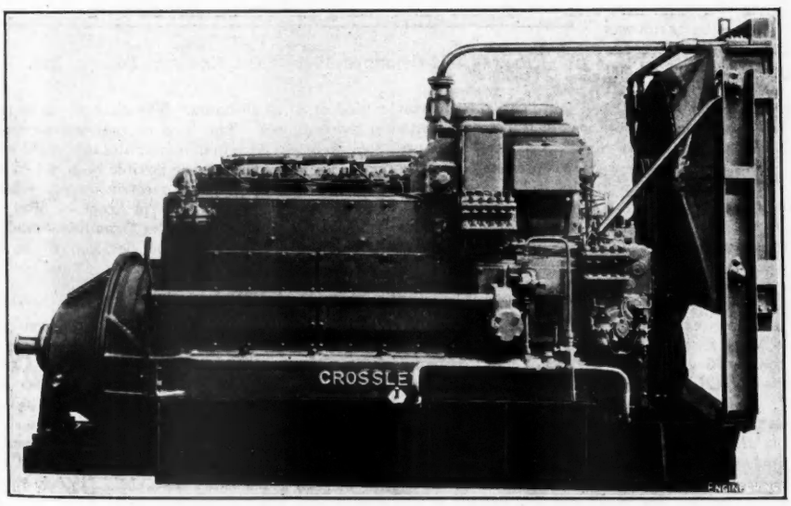

FIG. 41. 250-B.H.P. "PACKAGED" POWER UNIT; CROSSLEY BROS., LTD.

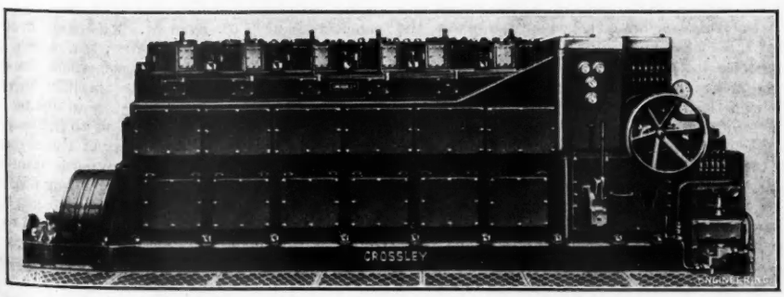

FIG. 42. 670-B.H.P. MARINE PROPULSION ENGINE; CROSSLEY BROS., LTD.

60-KW DIRECT-CURRENT GENERATOR SET.

Fodens Limited, Elworth Works, Sandbach, Cheshire, are exhibiting their marine two-stroke oil engines with powers ranging from 70 brake horse-power to 210 brake horse-power, and a self-contained 60-kW direct-current generator set with a radiator and built-in fuel tank. Fig. 43, page 290, illustrates the generator set, which is driven by an F.D.6 two-stroke six-cylinder supercharged compression-ignition engine with a continuous rating of 105 brake horse-power at 1,800 r.p.m. The generator set is also available with a 50-cycle 50-kW alternating-current generator. In both cases, the generators are of the single-bearing type, flange-mounted to the engine flywheel housing. Hydraulic speed governing is provided to British Standard 649.

The air-cooled radiator provides for both oil and water cooling; a large-capacity water header tank is fitted. The air flow through the radiator is furnished by a 25-in. diameter fan, belt-driven from the engine crankshaft. Thermostatically-controlled shutters are provided over the lubricating-oil portion of the radiator. The exceptionally cool running of the engine has made possible the use of aluminium-alloy exhaust manifolding, resulting in a considerable weight saving. The manifolding is air-cooled in the unit displayed, but in an alternative unit, which employs a tube-and-shell heat exchanger for oil and water cooling in place of the air-cooled radiator, fresh-water cooling is employed.

12-CYLINDER MARINE OIL ENGINE.

Also on view is the new Foden 12-cylinder 210 to 300 h.p. marine oil engine, the FD12, shown in Fig. 44, page 290. It is based on the six-cylinder heavy-duty road transport engine now in series production, and 95 per cent. of the parts are common to both engines. The Foden engine is a supercharged uniflow-scavenged two-stroke compression-ignition machine based on the Kadenacy principle. Two low-pressure Roots' blowers feed air to common air chests, from which it is delivered to the cylinders through ports in the cylinder liners designed to impart a high swirl. The exhaust valves in the cylinder head are operated by rockers and push-rods from a high camshaft. The injectors have single-hole nozzles, and can be removed without taking off the rocker boxes. A single aluminium-alloy casting, fitted with cast-iron wet liners, forms the crankcase and cylinder block.

Four cylinder heads, each covering three cylinders, are cast in a high-duty iron and incorporate the Foden system of fresh-water circulation. The two crankshafts are of nickel steel, with seven main bearings and hollow crankpins. Steel-back and white-metal bearings are used throughout. The camshafts, of hardened steel, are each carried in eight bearings. Two fuel pumps fitted with built-in filters, hydraulic governors and diaphragm fuel-lift pumps are mounted on top of the blowers. Lubricating oil is supplied by a gear pump driven from

ENGINEERING, MARINE AND WELDING EXHIBITION.

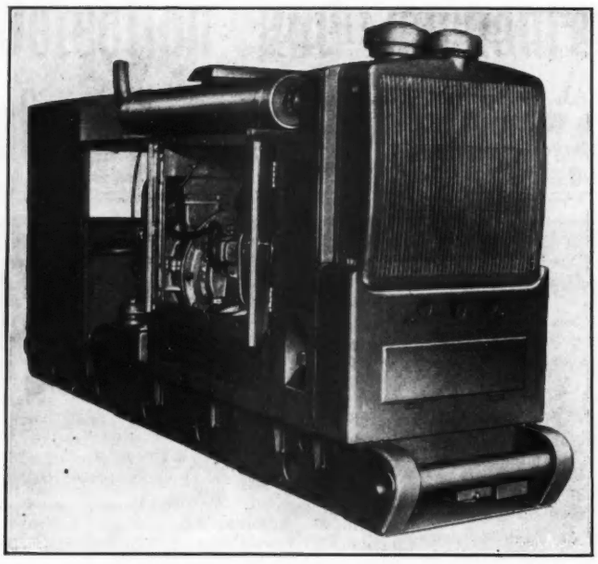

FIG. 43. GENERATOR SET; FODENS, LTD.

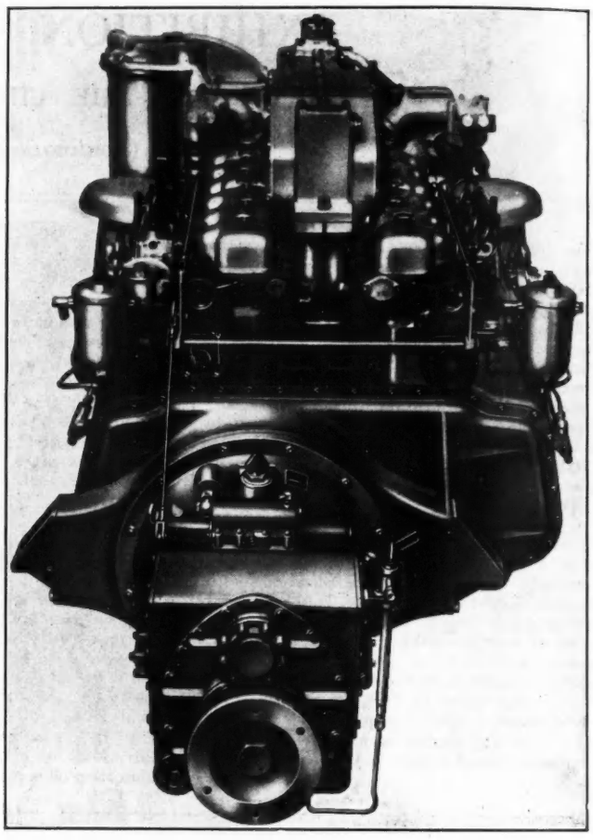

FIG. 44. 12-CYLINDER MARINE OIL ENGINE; FODENS, LTD.

the forward end of the engine, the oil being cooled in a tube and shell heat exchanger, through the tubes of which sea water is passed by a Megator sea-water pump. The engine-cooling system is of the fresh-water closed-circuit type, with a centrifugal circulating pump; a bypass thermostat maintains an even water temperature. Combined lubricating-oil and fresh-water Serck heat exchangers are carried in a cast-aluminium header tank which provides the necessary volume of fresh water. The tube stacks are interchangeable and can be removed for cleaning without dismantling the heat-exchanger header tanks. The exhaust manifold, cooled by the fresh-water system, is made in aluminium alloy; ahead or astern exhaust can be used with the same manifold by reversing it.

Hydraulically-operated reverse gears made by the Self-Changing Gear Company, Limited, are employed. A light-weight compact box may be fitted for direct-drive applications; alternatively a heavier box can be fitted to give a 2-to-1, 3-to-1 or 4-to-1 reduction ratio. The engine speed control can be interlocked with the gear control so that it is impossible to change from ahead to astern running with the speed above idling. The gearbox has a self-contained lubricating system with a separate sea-water oil cooler. A 24-volt electrical system is standard equipment.

The principal particulars of the 12-cylinder engine are as follow: continuous rating, 210 brake horse-power at 1,800 r.p.m.; intermittent rating, 240 brake horse-power at 2,000 r.p.m.; combat rating, 300 brake horse-power at 2,200 r.p.m. The bore is 85 mm. and the stroke 120 mm., giving a total swept volume of 8,180 c.c. The compression ratio is 14 to 1 and the piston speed, at 2,200 r.p.m., is 1,575 ft. per minute. The firing order, in each bank, is 1-5-3-4-2-6.

It is of interest to note that, since 1949, Foden engines have been undergoing type tests continuously at the Admiralty Engineering Laboratory, West Drayton. In the course of these tests, a six-cylinder engine has run over 11,500 hours with less than 0·001 in. wear on the crankshaft main and big-end bearings. Wear in the liners was less than 0·0005 in. per 1,000 hours, and the piston rings were still serviceable after 4,000 hours. The lubricating-oil consumption throughout the test was considerably less than 1 per cent. of the fuel consumption. The initial series of 500-hour endurance runs were made on a 24-hour load cycle based on a full load of 100 brake horse-power at 1,800 r.p.m., a period of 10 per cent. overload being included in every 24 hours, with the speed maintained at 1,800 r.p.m. This was followed by a 500-hour test in which low-load low-speed running alternated with high-load high-speed running, to give the severest possible conditions.

After this series of tests was completed successfully, a 4,000-hour run was carried out at 100 brake horse-power and 1,800 r.p.m., with overload periods. This was followed by a 2,000-hour run at 113 brake horse-power and 1,800 r.p.m., with overload periods, and finally, by 2,000 hours at 113 brake horse-power, with overload, in a simulated tropical temperature of 115 deg. F. In cold-starting tests, the engine was found to be capable of certain starting at 20 deg. F. with no external aids, using standard fuel and lubricating oil, and standard electric starting.

PORTABLE FUME EXTRACTOR.

The fume extracting unit shown in Fig. 45, Plate XVII, is one of the many exhibits being shown on the stand of Keith Blackman and Company, Limited, Mill Mead-road, Tottenham, London, N.17. It has been designed for removing the heat, fumes and dust that arise during a welding operation and is arranged so that it can be placed within a few inches of the actual zone of work. It comprises an electric motor, which can be supplied for three-phase or single-phase mains supply, driving a fan impeller of cast-aluminium alloy, both of which are mounted on a fabricated base fitted with three castoring wheels. The housing covering this unit carries a tubular bracket, which supports the end of the 3-in. diameter flexible hose; this hose is connected to the top cover of the fan housing at one end and its other end is fitted with a mild-steel suction nozzle, that can be placed near or clamped to the object that is being welded. The hose is available in standard lengths from 10 ft. to 35 ft. With the increase in the hose length the extraction capacity falls from 325 cub. ft. to 205 cub. ft. per minute, but the power used by the motor also falls so the change in the overall efficiency can be said to be negligible. The filtering unit is made from an asbestos cloth and it has over 1,000 sq. in. of filtering area, ensuring a low air velocity through its surface. It is recommended by the makers that the filter should be changed after a continuous working period of 35 to 40 hours. The change can be made in five minutes. The base of the unit occupies a floor area 1 ft. 8 in. in diameter and the height of the supporting bracket for the flexible hose is 4 ft. 3 in. The standard three-phase electric motor, which is enclosed by a circular type of fireproof filter, has received the approval of the Canadian Standards Association. The extractor is known as the "Tornado Weldafume" unit.

MINIATURE RECORDER FOR PROCESS CONTROL.

Evershed and Vignoles, Limited, Acton Lane Works, Chiswick, London, W.4, are exhibiting the miniature recorder illustrated in Fig. 46, Plate XVII, which has been developed mainly for use with process control apparatus. It records physical and other quantities which have been detected by various forms of electronic transmitter. It consists of a moving-coil milliammeter with a small continuous roll chart which has a scale 2 in. wide and is driven by a synchronous motor at a speed of $\frac{1}{2}$ in. per hour. The record is made by a high-speed tapping mechanism using an inked ribbon. The overall size of the front when flush mounted in a panel is about 6 in. by 4 in. The same firm are showing a high-response recorder, which has been designed to fill the gap between their standard recorder and the more elaborate amplifier-operated quick-response instrument. By re-designing the magnet system, it has been possible to increase the torque to about eight times that of the standard instrument. The adjustable magnetic damping, which is a feature of the older instrument, has, however, been retained and allows the damping to be adjusted from about 54 per cent. of critical to an over-damped condition. Thus, any degree of damping to suit the test in progress is at the disposal of the user.

A new "Megger" insulation tester is also on view on this stand. In this instrument, the

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(*For Description, see Page* 290.)

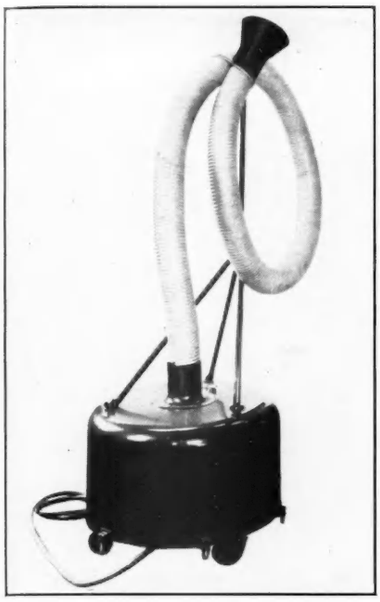


FIG. 45. PORTABLE FUME EXTRACTOR; KEITH BLACKMAN, LTD.

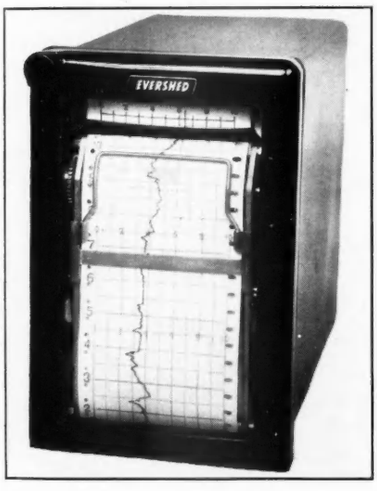


FIG. 46. MINIATURE RECORDER FOR PROCESS CONTROL; EVERSHED & VIGNOLES, LTD.

FIG. 47. WORM REDUCTION GEARBOX; MOTOR GEAR AND ENGINEERING CO., LTD.

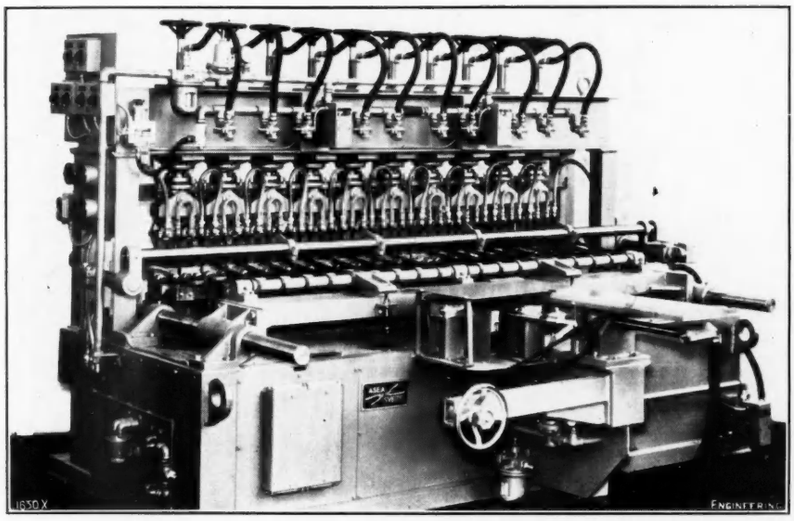


FIG. 48. AUTOMATIC WELDING PRESS FOR WIRE MESH; ASEA ELECTRIC, LTD.

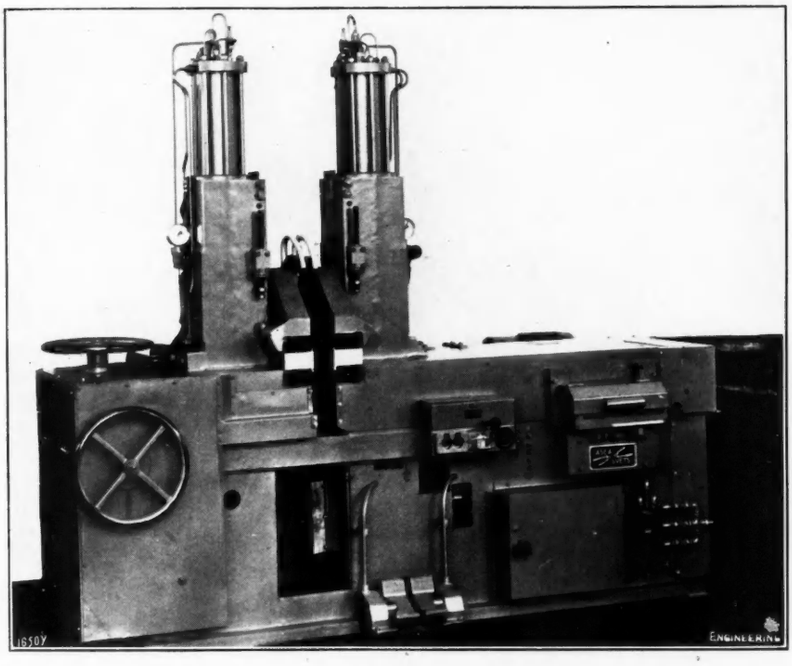


FIG. 49. AUTOMATIC FLASH WELDER; ASEA ELECTRIC, LTD.

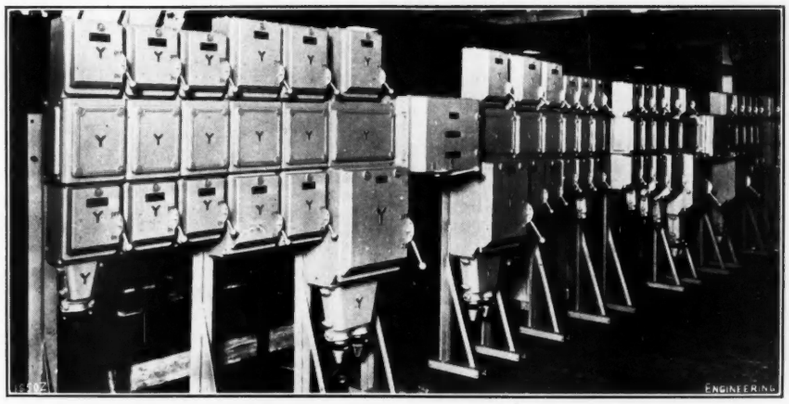


FIG. 50. FUSED SWITCHBOARDS FOR OILFIELD WORK; ELECTRO MECHANICAL MANUFACTURING CO., LTD.

(*To face page* 290.)

ENGINEERING, MARINE AND WELDING EXHIBITION AT OLYMPIA.

(*For Description, see Page* 291.)

FIG. 51. 50-TON PRESS; FINNEY PRESSES, LTD.

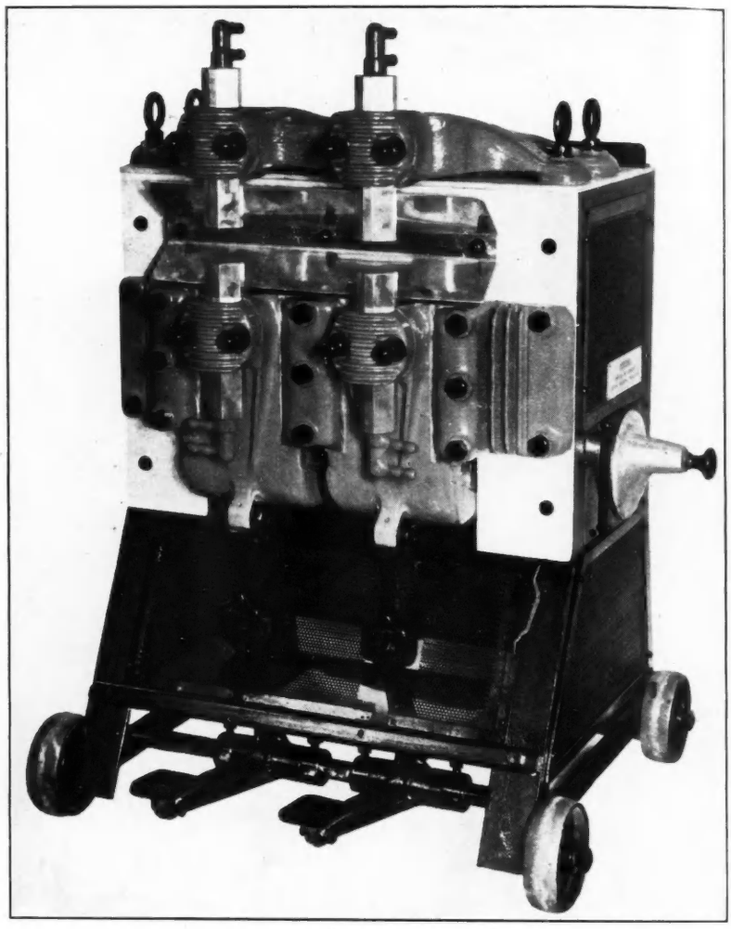


FIG. 52. TWIN-HEAD ELECTRIC RIVET HEATER; HOLDEN & HUNT, LTD.

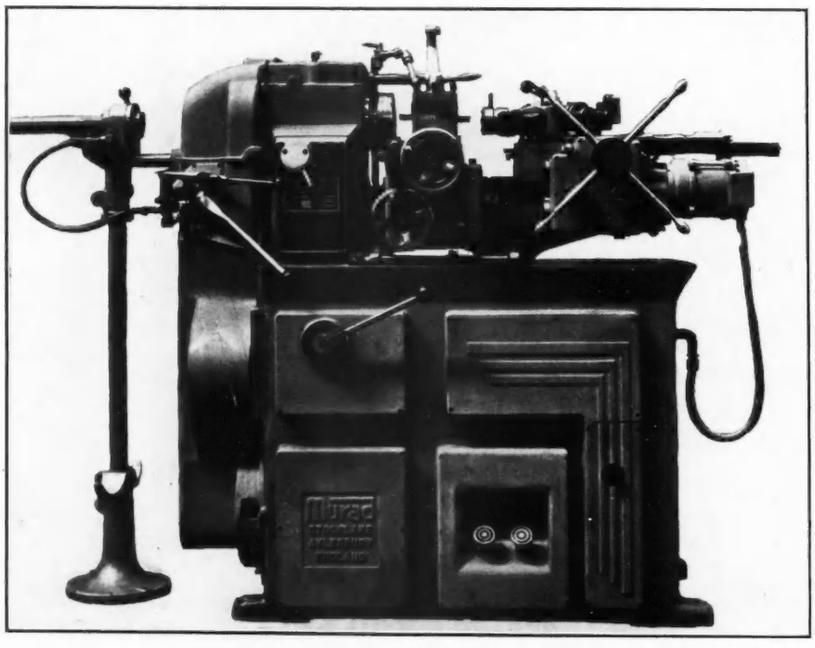


FIG. 53. 1-IN. CAPSTAN LATHE; MURAD DEVELOPMENTS, LTD.

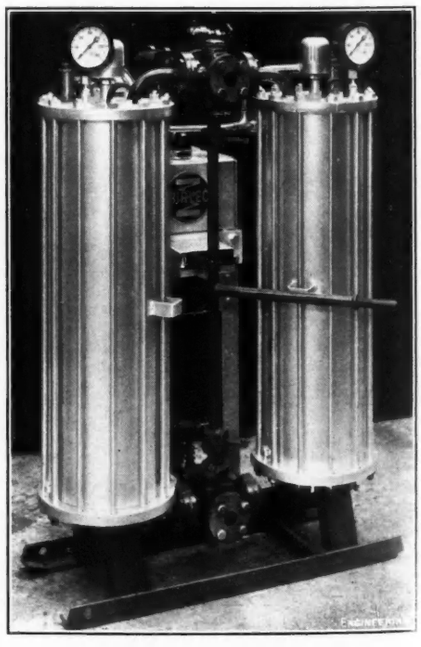


FIG. 54. COMPRESSED-AIR DRIER; BIRLEC, LTD.

(*To face page* 291.)

generator, which was used in the earlier models, has been replaced by a rectifier which is supplied from the alternating-current mains through a step-up transformer. Three testing voltages are available, namely, 1,000, 2,500 and 5,000 volts, the required value being selected by a switch on top of the instrument. The effect of mains-voltage variations has been almost eliminated, so that the instrument can be used for testing circuits of high capacitance. In order to ensure that such a circuit is not left in a highly charged condition after testing, an automatic switch disconnects the test terminals from the instrument and short-circuits them when the mains supply is switched off.

Worm Reduction Gearbox.

The Motor Gear and Engineering Company, Limited, Essex Works, Chadwell Heath, Essex, are showing for the first time a range of Motogear spur and worm reduction gearboxes. Their spur reduction geared motor units are available in four sizes and can be arranged for single, double or triple reduction, in 34 standard ratios ranging from 2 : 1 to 85·7 : 1. They are capable of transmitting up to 15 h.p., and can accommodate a wide range of motors by leading manufacturers.

Illustrated in Fig. 47, Plate XVII, is one of their new work gearboxes, which are made in two sizes, 4 in. and 6 in., with reduction ratios from 5 : 1 to 60 : 1. With a 5 : 1 reduction ratio, the 6-in. unit is capable of transmitting 31 h.p. and the 4-in. unit 13 h.p. A large fan coupled to the worm shaft provides a flow of cooling air over the casing fins and beneath the oil sump, ensuring rapid heat dissipation. The worm, integral with the shaft, is made from a high-grade nickel-alloy forging, heat-treated to give a high torsional core strength combined with a hard wearing surface. The wormwheel consists of a centrifugally-cast phosphor-bronze rim, shrunk and keyed on to the forged hub, which is integral with the output shaft and is in high-grade carbon steel. The worm shaft is carried in a roller journal bearing and a double-journal thrust bearing. The wormwheel is carried on two taper-roller bearings, of generous dimensions to allow for overhung loads. The bearings are positively lubricated. Oil collected from the worm-wheel rim by a baffle plate is fed through drilled holes to the wheel-shaft bearing, thence back to the sump.

Automatic Welding Press for Wire Mesh.

Asea Electric, Limited, Fulbourne-road, Walthamstow, London, E.17, are exhibiting a number of welding machines which have been constructed by Aseasvetsmaskiner A.B., of Stockholm. Among these mention may be made of the automatic press for wire mesh, illustrated in Fig. 48, Plate XVII. It consists of a frame on which ten 14-kVA transformers are mounted and two gables supporting an upper beam, which carries the same number of pressure cylinders, the operating pressure of which is 500 kg. These cylinders actuate the welding dies, which are fixed to a cradle, thus ensuring uniform pressure on the electrodes. A strip with nozzles for the warp wires is provided at the entrance to the machine and these wires are fed forward pneumatically by an air cylinder. This cylinder has a regulated length of stroke and operates an arm with the necessary number of pulling fingers at the rate of about 40 strokes per minute. During the forward movement towards the welding position these fingers are lowered so that they pass beneath the already welded mesh. When they reach the transverse wires of the mesh, which have just been welded, they are raised and grip the mesh wires. During their return stroke the welded mesh is fed forward for a distance corresponding to the stroke of the air cylinder. The weft wires may either be fed by hand or automatically from a table sloping towards the welding position, where they are held by fingers. The finer welded mesh is collected on a drum, while that of thicker gauge is cut to suitable flat lengths. The machine is designed to weld mesh made from wires from 2 mm. to 7 mm. in diameter and measuring from 25 by 25 mm. to 300 by 300 mm., depending on the size of the wire used. It is capable of producing from 8 to 15 sq. metres of finished mesh per minute, depending on the diameter of the wire and the size of the mesh. It is arranged for connection to a three-phase system and is provided with an electronic timer and phase shifter of the ignition type to ensure easy regulation. The stroke of each cylinder is adjustable so that any particular diameter of wire can be dealt with, a factor which enables the maximum number of strokes per minute to be obtained. The use of several transformers ensures that the current for each wire crossing is of the same value.

Automatic Flash Welder.

Asea Electric, Limited, are also showing the automatic flash welder illustrated in Fig. 49, Plate XVII. This has a clamping force of 9·8 tons at a hydraulic pressure of 852 lb. per square inch, and is provided with an automatically-governed motor-driven upset travel, the maximum upsetting force being 7 tons. It consists of a frame of rolled steel sections and sheet steel, which houses the transformer and the drives for the upset slide and the vertical and lateral adjustment of the machine table. The clamping devices form separate units, which are mounted on the machine table and upset slide, while the automatic control apparatus is enclosed in a separate box, which is usually mounted on the machine. The cast-iron machine table is carried on, but insulated from, the frame. The transformer, which has an output of 80 kVA on a 50 per cent. duty cycle, is of the shell type with primary pancake coils, from which 20 tappings are taken. The secondary winding consists of a single turn of high conductivity cast copper, to which copper water-cooling tubes are brazed. The primary insulation is mainly impregnated mica and is designed to withstand high mechanical and electrical stresses.

The upset slide is of cast iron and is provided with two round guides at one side and two flat guides at the other. These guides are placed inside the slide and are protected against flash and dirt by copper guards. The upsetting mechanism comprises a two-speed geared motor which drives a screw through gearing and a slip coupling. The lower speed is used for pre-heating and flashing and the high-speed for upsetting. The clamping devices consist of a bracket carrying high-conductivity water-cooled die holders, one of which is fixed and the other movable. Both the clamping movement and the clamping pressure can be effected either pneumatically or hydraulically, the pressure being adjustable. The movement of the dies, which are generally of hard-hammered copper with flat clamping surfaces, is governed by pedals, the control being such as to enable clamping and de-clamping to be effected rapidly and the pressure to be set and maintained at a pre-determined value.

An automatic regulator is provided for pre-setting the die-spacing before welding and for adjusting the flashing and upsetting lengths, so that the pre-determined ultimate length of the work is obtained after welding within the limits of some tenths of a millimetre. In operation, the relays and contactors, all of which are of the metal-clad type, first advance the upset slide so that the pieces to be welded are brought into contact with each other. The motor and the slide are then reversed and again advanced, these movements being governed by a voltage relay so that the heat generated by the current is distributed over the faces of the butting ends. As the temperature approaches that necessary for welding, the tension across the dies is increased, and when the correct value has been reached the reversals are stopped, so that the upset slide continues to advance and flashing begins. After the pre-set flashing length has been obtained, the speed of the motor increases and upsetting takes place. The motor is finally switched out by an adjustable stop and braked, and the welding current cut off.

Fused Switchgear for Oilfield Work.

Fig. 50, Plate XVII, illustrates switchgear for motor control which is made by the Electro Mechanical Manufacturing Company, Limited, Scarborough, to comply with the arduous conditions of oilfields and refineries. It consists of a number of fine-grain aluminium castings which have been accurately machined so that they can be bolted together to form a switchboard and contain the various items of the control gear. The 'bus-bar chamber is made up in units and contains unit 'bus-bar sections of electroplated hard-drawn copper strips, which are interconnected by links of the same material, thus giving maximum flexibility when extensions are required. The boxes containing the starters have hinged lids in which there are windows so that "on" and "off" mechanical indicators can be seen. The contactors employed are manufactured by the Electrical Apparatus Company, Limited, and are provided with overload and single-phasing protection, which is calibrated for the particular motor rating. The English Electric Company's type of high rupturing capacity fuse can also be provided, mounted in a separate box with a hinged access cover and connected between the 'bus-bars and the starter. An isolating switch is housed in a chamber similar to that of the fuse box and is connected directly to the 'bus-bars. The contacts of this switch are of the heavy-pressure line type and have double breaks, a horizontal push-pull arrangement being provided for their operation. There is also an auxiliary switch with silver-plated contacts which break before the main contacts, thus providing an electrical interlock with the contactor and ensuring that the normal load is always broken by the latter. Both quick-make and quick-break are obtained by the use of a spring. An insulating barrier is fitted over the opening between the isolator switchbox and the 'bus-bar chamber to separate the motor control unit from the 'bus-bars and to prevent the passage of ionised gases into the 'bus-bar compartment. Remote control by push buttons can be fitted.

50-Ton Press.

The Greer-Mercier pneumatic-hydraulic accumulator is fitted to the press shown in Fig. 51, Plate XVIII, which is exhibited by Finney Presses, Limited, Birmingham, 1. Such an accumulator is required for storing fluid pressure, intensifying power in intermittent cycles and absorbing water hammer in hydraulic pressure lines; in the illustration, the accumulator is used in conjunction with a 50-ton up-stroke press, for the purpose of storing power for intermittent use. The accumulator consists of an air-bag in a steel container. The container is drawn from high-tensile steel, is free from welds and seams and is stress-relieved by heat treatment; the air-bag is of synthetic rubber and merely serves to separate the air within it from the oil, or water, within the container, whose volume is approximately half that of the air-bag at atmospheric pressure. When operating, the air-bag is first set, or loaded to a pre-determined pressure, by pumping in air at any pressure up to the limit of 3,000 lb. per square inch; in this process, of course, the air-bag rapidly expands to the limiting volume set by the container. Oil or water is then pumped in at the bottom of the container, and when the oil pressure within the container equals the air pressure within the air-bag, a state of equilibrium is reached with the air-bag subjected to no strain whatever and returned to the same size as it had at atmospheric pressure; in these circumstances, the air-bag merely "floats" in the container. When the demand on the pressure pump is greater than it can momentarily supply, the compressed air within the air-bag causes it to expand and instantaneously expel the contents of the cylinder, which thereby makes up the difference.

Twin-Head Electric Rivet Heater.

Holden and Hunt, Limited, Cox's Lane Works, Old Hill, Staffordshire, are showing examples of their spot and butt welders and rivet heaters. These include a small bandsaw welder and two automatic butt welders of 3 and 8 kVA capacity, respectively, which should be of interest to wire workers and both ferrous and non-ferrous mills. The 16-kW twin-head heavy-duty rivet-heating machine illustrated in Fig. 52, Plate XVIII, is capable of heating rivets up to ¾ in. in diameter and 4 in. long and is particularly designed for structural engineering work. It operates on the principle that a high current at about 2 to 3 volts is caused to flow from one copper-bar electrode to another through the rivet, which is gripped by mechanical spring pressure between them. Owing to high resistance of the metal, usually mild steel, of which the rivet is made, heat is thus generated and the necessary riveting temperature is reached in a few seconds. The resulting consumption of elec-

tricity varies from 1½ kWh per 100 ⅜ in. by 2 in. rivets to 10 kWh per 100 ⅜ in. by 3 in. rivets, although these figures vary slightly, depending on the speed of heating, the conditions of the rivets and the temperature required.

The machine consists of a welded steel frame forming a body enclosing the transformer and input terminals. This body is mounted on cast-iron wheels, so that it can easily be moved, and has eye bolts for lifting purposes. Two rivets, which may be of different length, can be heated simultaneously or one may be heated alone. The electrode holders are hard copper castings, finned for cooling. The electrodes themselves are blocks of the same material and are generally air-cooled. Water cooling can, however, be provided. The blocks are adjustable for wear and length of gap in the open and closed positions, the electrode travel being 1½ in. In action, the operator presses a pedal, which is connected to the bottom electrode, and places the rivet in the gap between it and the upper electrode. When the pedal is released the rivet is gripped between the two electrodes. Heating then begins and continues until the correct temperature has been reached. The rivet is next held by a pair of tongs and the pedal pressed so that removal can be effected. The current necessary to suit rivets of various diameters and lengths can be adjusted by a four to six speed totally-enclosed voltage regulator, which is operated from the side of the machine. Single-phase current is necessary for operation, a supply of which can be obtained either from the lighting circuit or by connecting the welder across two phases of a three-phase system.

1-In. Capstan Lathe.

Among the exhibits that are displayed on the stand of Murad Developments, Limited, Stocklake, Aylesbury, Buckinghamshire, is a capstan lathe, model No. 1B, which has recently been introduced by them and is shown in Fig. 53, Plate XVIII. It has 16 spindle speeds in either direction without stopping the spindle, in four groups of four speeds from 62 to 1,800 r.p.m. A two-speed change-pole motor drives the two-speed gearbox, from which the drive is taken to the main spindle by a V-belt. The motor, which is designed for three-phase supply, develops 1 h.p. at a speed of 720 r.p.m. and 4 h.p. at its other speed of 2,800 r.p.m. The choice of motor speeds is controlled by two pedals in the sunk panel at the base of the machine. The speed changes in the gearbox are controlled by the lower lever, shown at the left in the illustration. There are three control positions: high, low and neutral. In the neutral position, inward pressure on the lever applies the spindle brake, but it cannot be applied when the lever is in either of the other two positions. The brake, which is automatic in action, is applied when the reversing lever reaches the neutral position, and it is also automatically applied when the motor stop-button is pressed.

The lathe now has automatic feeds to the turret slide. Six rates of feed from 0·34 in. per minute to 10·8 in. per minute are available, and the engagement is by a drop type of worm mechanism. The feed is automatically released by the turret-slide stops. The feed may also be manually released at any stage. The gearbox is driven by a separate motor, driving through an adjustable clutch fitted with a spring type of over-load safety device. All the gears are lubricated from a plunger type of cam-operated pump. Indexing stop-bars provide a positive control of the depth of cut in both directions. All the gears and bearings in the apron are automatically lubricated. A four-way tool-post is fitted as standard equipment. The swinging type of stop and the adjustable rear tool-post that are fitted are said to be of considerable assistance in setting-up. The coolant pump, driven by a separate motor, is located in a recess in the rear of the pedestal and can be withdrawn for servicing. The multi-plate clutch runs in oil in the gearbox, and access of adjusting the clutch can be gained through an opening in the rear of the machine. The collet will take bars up to 1 in. in diameter, and the diameter of the hole through the spindle is 1⅛ in. The swing over the bed is 11½ in. and the maximum possible swing over the cross-slide is 6 in. The sliding saddle and cross-slide have a total movement along the bed of 7 in. and a movement across the bed of 4½ in. The maximum distance between the front of the collet and the turret is 16 in. and the useful stroke of the turret slide is 4½ in. The tool holes in the turret are 1 in. in diameter.

ENGINEERING, MARINE AND WELDING EXHIBITION.

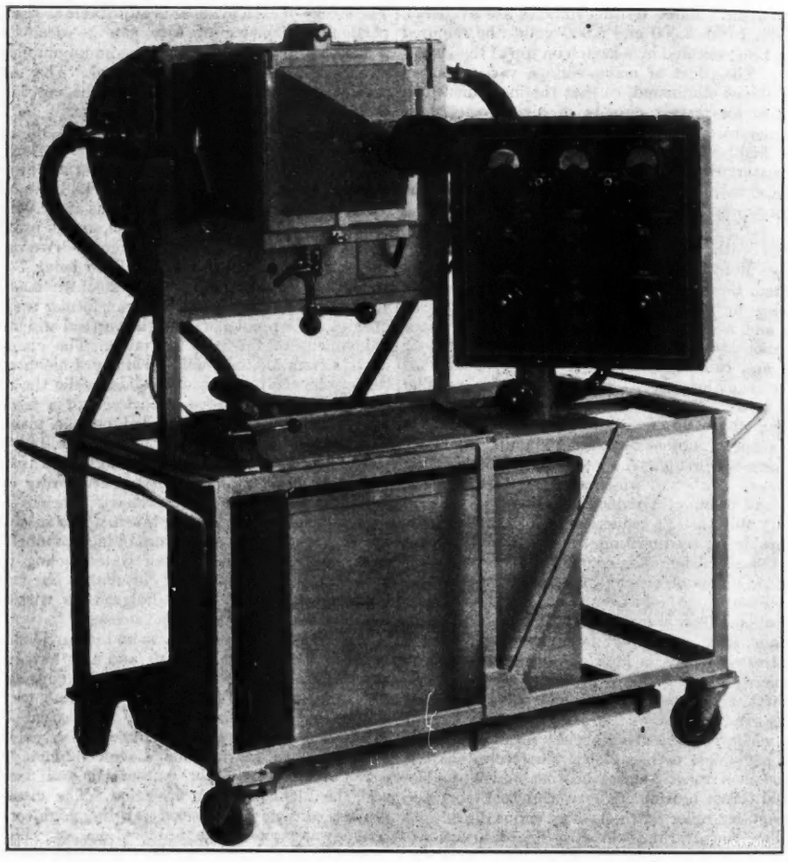


Fig. 55. Mobile Fluoroscopy Unit; Solus-Schall, Ltd.

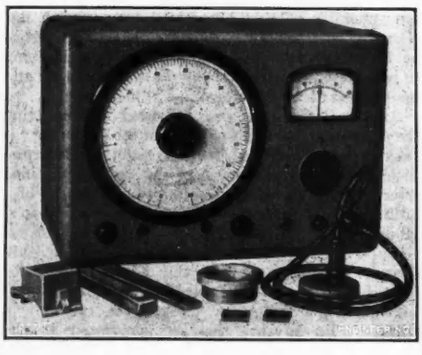


Fig. 56. "Sigmatest" Conductivity Meter; Solus-Schall, Ltd.

Compressed-Air Drier.

Messrs. Birlec, Limited, Tyburn-road, Erdington, Birmingham, 24, are exhibiting a number of their Lectrodryers, which have been designed to reduce the moisture content of air (particularly compressed air), gases and certain organic liquids and thus to maintain an inert or reducing atmosphere, so that hydrolisis or freezing is prevented. They can be used to obtain a dewpoint of — 70 deg. C. when extreme dryness is required, and the relative humidity can be maintained at 5 to 10 per cent. The operating pressures extend up to 4,500 lb. per square inch. A typical drier of this type, which is intended for drying compressed air, is illustrated in Fig. 54, Plate XVIII. It consists of two welded mild-steel cylinders, which are mounted on a steel framework and comply with the American Society of Mechanical Engineers' Code for unfired pressure vessels. In the base of each cylinder is a wire-mesh disc, which is supported on a steel grid and serves to carry the adsorbent material. The cylinders are suitably lagged to minimise the heat requirements for reactivation, and are fitted with pressure gauges and safety relief valves. They are charged with activated alumina of appropriate grade and mesh size. This material is a highly efficient moisture adsorber and is capable of performing repeated adsorption and reactivation cycles without deterioration of its efficiency. In normal service it only requires replacement at long periods.

The cylinders are interconnected by four-way plug valves, the operation of which allows the airflow to be directed to one cylinder while the contents of the other are undergoing reactivation. The valves are opened or closed simultaneously by an electric motor which drives through gearing, or by compressed air. They are operated by an automatic timing device. A bleed connection is provided so that full pressure is maintained in the cylinder undergoing reactivation. During operation a proportion of the incoming air is passed over a heater, which consists of an insulated pressure vessel heated by steam or electricity. It is then passed through one cylinder, which is thereby heated to reactivate the adsorbent material. On leaving the vessel the air, which is now laden with moisture, is passed through a condenser where it is cooled and its moisture content reduced to about the value it originally possessed. Finally, the air stream is

ENGINEERING, MARINE AND WELDING EXHIBITION.

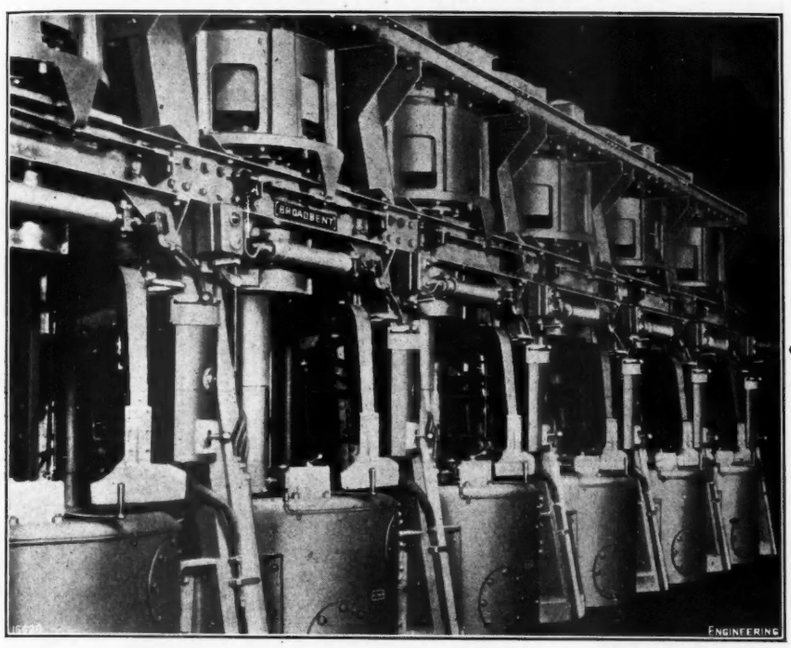


FIG. 57. SUGAR CENTRIFUGAL; THOMAS BROADBENT & SONS, LTD.

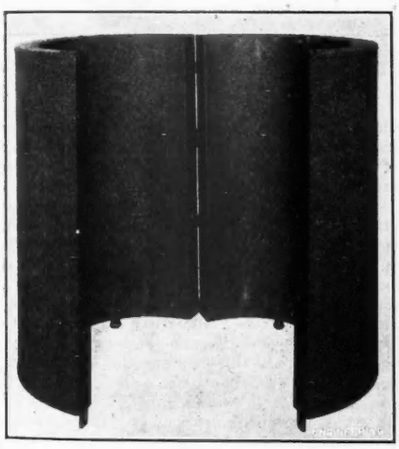


FIG. 58. ELECTRIC SURFACE HEATER FOR DRUMS; ISOPAD, LTD.

FIG. 59. ELECTRIC HEATER FOR SULPHONATING POT; ISOPAD, LTD.

passed through the active adsorber where it is dried to the specified moisture level.

Two of the dual units on view at the exhibition are manually operated, one being intended to dry out refrigerator tubing at a pressure of 100 lb. per square inch and the other to fill a supersonic wind tunnel at a pressure of 60 lb. per square inch. The third unit is fully automatic and, in conjunction with a circulating fan, is designed to maintain a relative humidity of 35 per cent. in a store room with a cubic capacity of 1,750 cub. ft.

MOBILE FLUOROSCOPY UNIT.

The apparatus illustrated in Fig. 55, page 292, has been designed by Solus-Schall, Limited, 18, New Cavendish-street, London, W.1, for the fluoroscopic examination of small assemblies and mass-produced parts. It can also be used for the routine examination of light-alloy castings, pipe welds and canned foodstuffs. It consists of two 75-kV peak-voltage oil-immersed transformers, each of which incorporates a hot cathode valve and filament transformers, as well as a shock-proof and ray-proof oil-immersed X-ray tube and cooling pump. The specimen is placed on a movable table in a ray-proof box, which can be controlled by external levers. In a modified design, this box can be arranged to admit a continuous flow of articles. The fluorescent screen, which is protected by lead glass, is observed through an eye-piece which excludes daylight. Access to the inside of the box is obtained through a door which, when opening automatically, shuts off the X-rays. The apparatus is mounted on a steel trolley which is provided with rubber-tyred wheels. On the switch panel, which is provided for control purposes, is mounted a mains-voltage compensator and voltmeter, a kilovolt-meter and milliameter and a pre-setting timer for exposures from 0 to 12 minutes. There are also controls for the kilo-voltage and tube current. A cooling unit, which is located on the trolley below the control unit, provides a supply of radiator-cooled oil which circulates round the X-ray tube.

"SIGMATEST" CONDUCTIVITY METER.

Another apparatus on this stand is the Sigmatest meter illustrated in Fig. 56, opposite. This has been designed to measure the conductivity of non-ferrous materials and to record changes in its value, which will be indicative of a number of varying conditions. Thus the conductivity measurements can be used to indicate contaminations in light-metal castings or in melts, as well as for the identification of non-ferrous alloys and for sorting scrap. The instrument will also give an indication of the hardness of materials and their variation with age and can further be employed to reveal cracks. Its operation depends on the fact that most impurities in metals affect the electrical conductivity, so that even very small traces of contamination can be detected. The readings can be obtained to a high degree of accuracy either in absolute units or in comparison with a known standard.

Messrs. Solus-Schall are also showing two types of isotope containers in which γ-ray sources can be carried and used for exposure without danger to the operator. Both have exactly the same external appearance, except that one is coloured red and the other green. The former is lined with lead and is designed to take iridium 192 or very small sources of isotopes with higher energy. The other is lined with tungsten alloy and is intended for cobalt 60 and other similar high-energy isotopes. The distinguishing feature of these containers is that the γ-ray source is housed in the centre and is positioned so that its radiation can be directed inwards or outwards. When it passes inwards the protective material prevents emission in excess of the permitted intensity. On the other hand, when it is directed outwards the radiation forms a cone of rays, the centre line of which is clearly defined. The carrying handle is arranged so that radiation cannot take place while the unit is being moved.

SUGAR CENTRIFUGAL.

Thomas Broadbent and Sons, Limited, Central Ironworks, Huddersfield, are displaying for the first time a high-duty sugar centrifugal of the type shown in Fig. 57, which shows a battery of centrifugals installed in South Johnstone, Queensland, Australia. The modern high-speed sugar centrifugal (the purpose of which is to separate the sugar crystals from the adhering molasses) is required to give high production during the crushing season, which normally lasts only three or four months; during this period, the centrifugal must operate for 24 hours a day, and complete reliability is therefore essential.

The operation of the centrifuging cycle is as follows: the massecuite is thoroughly mixed in a tank and is admitted to the centrifugal by a power-operated massecuite feed valve of the gate type, with finger-tip control. Emergency hand gear is provided to close the valve in the event of a power failure. When the basket of the centrifugal is fully charged, it is accelerated and under the action of centrifugal force the molasses are forced through the perforations of the basket, leaving the solid crystals in the basket in the form of a wall or cake of sugar. When the molasses have been completely separated, the basket speed is reduced and a central bottom discharge valve is opened. The crystals are then ploughed through the discharge valve by a plough inserted into the basket. The centrifugal exhibited incorporates a Poppleton basket, developed by the Broadbent company within the last few years, in which the discharge valve, an integral part of the basket, is opened automatically when the plough is brought into action, and is closed automatically when the plough is returned to the locked position clear of the machine. The plough requires no maintenance other than the occasional replacement of a plough tip. Usually, the ploughed sugar crystals are removed on conveyor belts.

The Broadbent centrifugal is driven by a high-torque two-speed squirrel-cage motor, in which the ploughing speed is obtained by feeding a low-frequency supply to the main motor, eliminating the complications of a mechanical change-speed drive. The motor is cooled by continuous forced ventilation from a separate motor-driven fan. There is no flexible connection between the driving motor and the basket, the rotor being directly mounted on the main centrifugal spindle; the weight distribution and suspension ensure freedom from vibration. At the end of a cycle, electro-dynamic

braking, controlled by a process timer, operates from full speed to half speed, and mechanical braking is then automatically applied to stop the machine.

The machine is controlled from a master controller with two levers, controlling, respectively, the machine speeds and process times, and the massecuite feed. The process timer controls washing or steaming, molasses clarification, length of spin, and braking. Washing is carried out by power-operated oscillating jets arranged to give an even wash over the total cake depth, and is arranged to leave the basket interior clear of pipework.

Also on view on the Broadbent stand is a 30-in. inclined ploughing centrifugal for batch treatment in chemical processes; a 21-in. rigid-bearing centrifugal in corrosion-resisting materials for a wide range of chemical processes; and an automatic centrifugal clutch coupling, available in various sizes for powers up to 40 h.p.

Electric Surface Heater for Sulphonating Pot.

Among a range of electric surface-heating equipment exhibited by Isopad, Limited, 30-32, Rosemont-road, London, N.W.3, is the Isomantle illustrated in Fig. 59, page 293, with a loading of 4 kW arranged in three horizontal circuits. It is shown heating and supporting a 20-gallon cast-iron sulphonating pot. In the Isomantle, the heating surface consists of a high-temperature glass cloth capable of withstanding 550 deg. C. A fully-insulated resistance cord is applied to this surface to form horizontal circuits which can be independently controlled. Glass-wool thermal lagging, 2½ in. to 3 in. thick, ensures a heat transfer efficiency of 95 per cent. The heating unit and lagging material are enclosed by a strong metal cover which also supports the weight of the unit to be heated. This type of construction is used for vessels up to 200 gallons. Temperatures up to 400 deg. C. in the liquid can be attained. The controls provide for accurate process temperatures; any desired heat gradient can be obtained by a "dual-control" system with control points on the Isomantle and in the liquid.

Electric Surface Heater for Drums.

Also on view, and shown in Fig. 58, page 293 is an electric drum heater, known as the Isodrum heater, rated at 4 kW, for drums of 40 to 50 gallons capacity. It is made in two hinged sections mounted on ball castors so that the heater can easily be placed round the drum. The Isodrum heater acts as a movable oven radiating at black heat. The drums can be emptied by melting a small layer of solidified material next to the drum wall, with the remainder of the contents ready to drop into a larger container. Alternatively, where the material is removed by dipping, pouring or pumping, it is heated at a rate of 14 deg. to 33 deg. C. per hour. The whole cylindrical surface of the drum is heated uniformly. The heating unit is an Isopanel containing fully-insulated heating elements interwoven with glass yarn. A thick layer of glass-wool lagging gives a high heat-transfer efficiency. The heating assembly is enclosed in a metal casing. Where materials of poor thermal conductivity are to be heated, circular metal base heaters are employed to start convection currents, reducing the heat gradient in the material to a minimum.

The Isopad company are also showing silicone-rubber-covered waterproof and weatherproof flexible electric heating panels and tapes, in which the heating elements are interwoven with high-temperature glass yarn. A layer of silicone rubber applied to either side of the heating element forms a coating of high-temperature waterproof material, with the heating element forming an integral part of the assembly. These units can operate continuously at temperatures up to 200 deg. C. under very moist conditions, or even immersed in liquids. They are produced in standard sizes from 1-in. to 36-in. widths, up to 144 in. long.

Similar flexible heaters employing a glass-cloth covering instead of silicone rubber are suitable for temperatures up to 450 deg. C. Such units are employed for tracing pipelines, and for heating vessels of any size. Standard Isotapes are 1 in. to 4 in. wide and 2 ft. to 50 ft. long. Isopanels are available in 30 standard sizes and 90 standard loadings up to 7 kW per unit.

ENGINEERING, MARINE AND WELDING EXHIBITION.

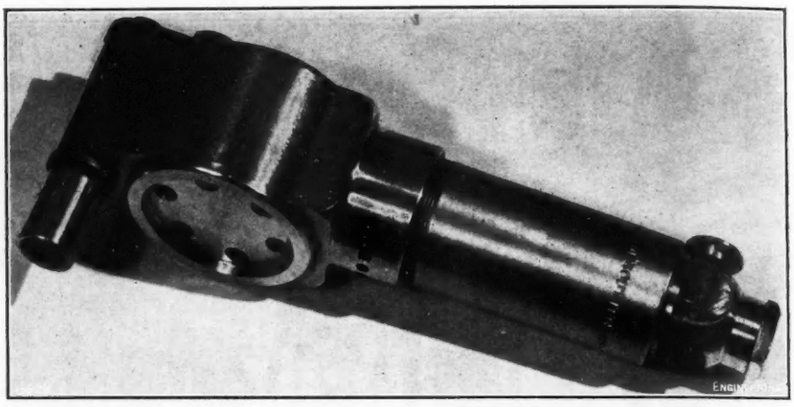


Fig. 60. Nut-Runner for Use in Corners; Desoutter Bros., Ltd.

Fig. 61. Corner Drill; Desoutter Bros., Ltd.

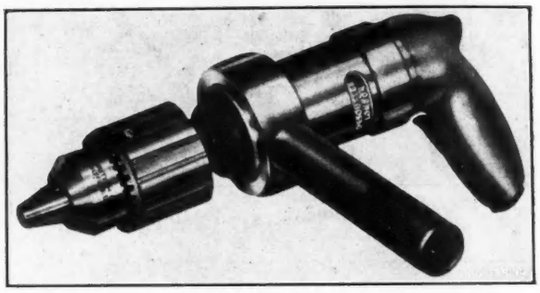


Fig. 62. ½-in. Pneumatic Drill; Desoutter Bros., Ltd.

Pneumatic Drills and Tools.

Desoutter Brothers, Limited, The Hyde, Hendon, London, N.W.9, are demonstrating two new series of pneumatic straight drills of ⅜-in. and ½-in. capacity, fitted with the SR pneumatic motor. The latter, which was described on page 329 of our 174th volume (September 12, 1952) is particularly compact and light in weight, and develops over ⅝ h.p. One of the ½-in. drills is illustrated in Fig. 62. Both series of drills are fitted with an adjustable exhaust sleeve which can be rotated to discharge the exhaust air in any direction. A detachable side-handle, which can be quickly adjusted to suit a particular drilling operation, is a standard fitment on the ½-in. drills, and can be supplied as an extra on the ⅜-in. drills.

Also on view is a new pneumatic corner drill, illustrated in Fig. 61, capable of drilling $\frac{17}{64}$-in. diameter holes in steel to within $\frac{17}{32}$-in. of the inside face of a right angle. In Fig. 60 is shown a new corner nut-runner designed for running down nuts in almost inaccessible positions. It is compact and light in weight and is, therefore, particularly suitable for use by female operators. After running the nut down, the tool is used as a ratchet spanner. The nut cannot be over-tightened, since the motor is automatically driven in reverse against the air pressure when the required torque is attained. This torque can be controlled to fine limits by regulating the air pressure through a reducing valve.

Compression and Transverse Testing Machine for Concrete.

Samuel Denison and Son, Limited, Hunslet Foundry, Leeds, 10, are exhibiting a wide range of their testing machines. The models include, among others, two universal machines, a 150-ton compression machine and one for high-temperature creep testing. A new machine on exhibition is that illustrated in Fig. 63, opposite—a compression and transverse bending machine having a load capacity of 10,000 lb., which has been designed for testing pre-cast concrete kerbs, edgings, flagstones, etc.

The machine is designed on the weighing-lever principle with the load applied by a non-rotating straining screw controlled by the large handwheel on the front of the machine. The indicator mechanism, reading in increments of 50 lb., works on the principle of a steelyard and is fitted with a motorised poise weight so that uniform rates of loading are applied. The operator turns the handle at such a rate as to maintain the steelyard in a floating position. The main column carrying the straining gear is an overhung design, which, as may be seen from the illustration, gives easy access to the specimen table. All the controls are grouped together on the front of the machine, so that the operator is able to keep both the indicating mechanism and the specimen under easy observation. The standard electrical equipment is for 400-volt 3-phase 50-cycle current.

Manual Continuous Welding Machine.

Among the exhibits of Fusarc, Limited, Team Valley, Gateshead, Co. Durham, mention may be made of the continuous welding machine illustrated in Fig. 64. This consists of a carriage mounted on castors and carrying a control cubicle which can be rotated through 360 deg. The cubicle is fitted with a counterbalanced arm, which supports the cable by which connection is made to the welding head. It thus relieves the operator of its weight, gives greater freedom of movement, and keeps the floor clear. The drive unit on the head feeds the electrode and traverses the welding head through one of the castor wheels, which is power driven. Both these actions can be independently controlled by thumb switches which are fixed on the right and left handles of the machine. The welding conditions for a particular job can be pre-set on scales on the upper face of the head. The operator has therefore only to make slight adjustments to the rate of feed as welding proceeds in

ENGINEERING, MARINE AND WELDING EXHIBITION.

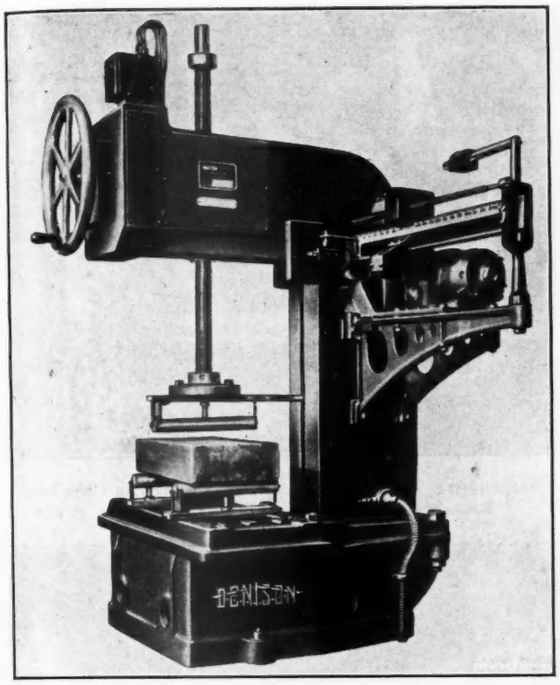


FIG. 63. COMPRESSION AND TRANSVERSE TESTING MACHINE FOR CONCRETE; DENISON & SON, LTD.

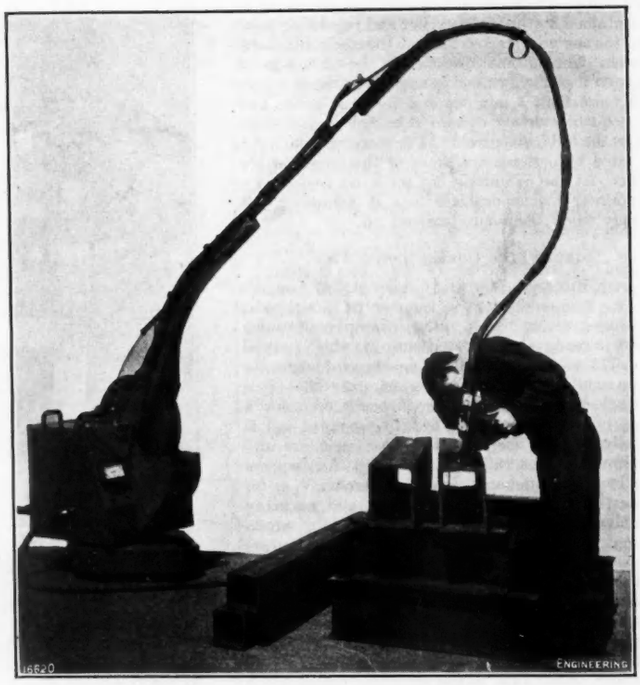


FIG. 64. MANUAL CONTINUOUS WELDING MACHINE; FUSARC, LTD.

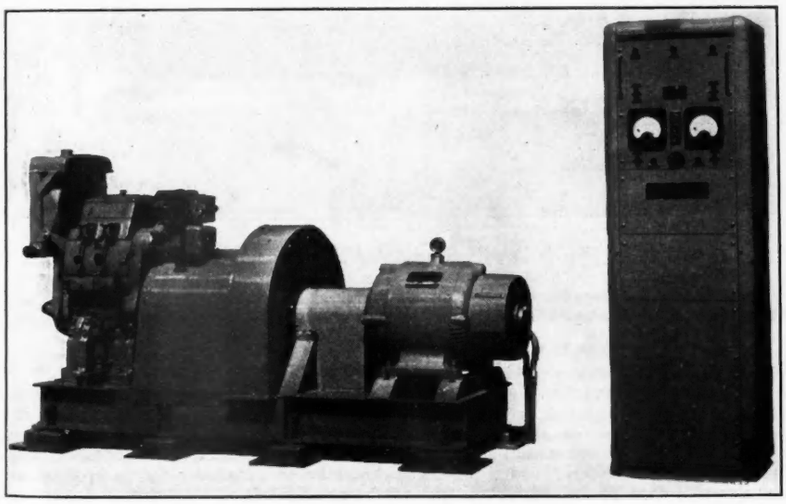


FIG. 65. DIESEL-DRIVEN ALTERNATOR; ELECTRIC CONSTRUCTION CO., LTD.

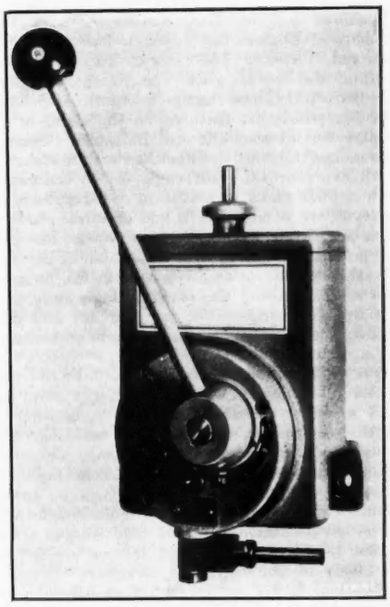


FIG. 66. SINGLE-LINE GREASE LUBRICATOR; TRIER BROS., LTD.

order to maintain an even arc length. The nozzle assembly and feed gear incorporate spring-loaded copper conducting jaws and a dual drive, which gives a positive feed. The arc is viewed through a built-in shield, so that the operator is not inconvenienced by heat. Fatigue is minimised by supporting the head on its driving wheel in such a way that balance has only to be maintained round that point. A disperser, which is driven by the head motor, blows fumes away from the operator. It is stated that the use of this machine, in conjunction with the firm's continuous electrodes, enables welding currents as high as 600 amperes to be employed. Greatly increased welding speeds are thus possible and a rate of output at least twice that obtainable with manual welding can be reached. For instance, a $\frac{5}{16}$-in. horizontal-vertical fillet can be deposited at the rate of 17 in. per minute and a $\frac{1}{2}$-in. two-pass close square butt at 20 in. per minute on either side without stopping to change electrodes.

DIESEL-DRIVEN ALTERNATOR.

The stand of the Electric Construction Company, Limited, Wolverhampton, has a background showing the progress made by the firm during six reigns. With the same object in view, the exhibits include a direct-current motor complete with switch panel, which was made during the eighties of last century, and, coming to more modern times, a continuity alternator set with a "no-break" feature, which has been designed for use on telecommunication and other essential services. This set, shown in Fig. 65, consists of a Lister cold-starting Diesel engine coupled to a three-phase synchronous alternator of the screen-protected induction type. The two machines are mounted on a common bedplate, together with their flywheel, pedestal bearings, flexible couplings and electromagnetic clutch, and the alternator is connected to a control panel in a sheet-steel cubicle, on the front of which are an ammeter and voltmeter and warning lamps for indicating oil-pressure or mains failure. There is also a control switch with its operating push-buttons and equipment for automatically synchronising the alternator with the mains supply. Inside the cubicle is automatic equipment for starting the alternator, a self-regulating static exciter for providing the excitation of the machine, both when motoring and when generating, and various contactors and control relays.

The flywheel is of sufficient size to ensure that the frequency does not fall below 45 cycles when the 50-cycle supply fails. In fact, during this 10 per cent. drop, the full-load output of the alternator is maintained by the static exciter and regulating unit, and the engine is started through the electromagnetic clutch. The automatic starter on the control panel ensures that the flywheel is accelerated from rest in not more than 5 minutes and that the initial and subsequent starting current does not exceed three times the full-load current. The starting equipment is rated to perform one start of this duration per hour. At the exhibition the set is connected to a teleprinter to demonstrate how it maintains the supply when the mains are cut off.

Single-Line Grease Lubricator.

Trier Brothers, Limited, Caldew-street, London, S.E.5, are exhibiting a number of multi-point pressure-greasing units, earlier examples of which have already been described in this journal (vol. 172, page 576, 1951). A new type of lubricator being exhibited is shown in Fig. 66, page 295. It is a single-line model capable of being used for a large number of greasing or oiling points, and is equally suitable for special-purpose machines and machine tools generally. Each installation requires one hand-operated unit as shown (model V.A. for grease or V.B. for oil lubrication), and as many distribution elements as there are points of application. "Stauffer lube Multigreasors," as they are termed, have no springs or valves and are suitable for severe operating conditions, as in steelworks, quarries, cranes, dredgers, etc. A feature of this firm's exhibits is their "Collgraf" system of oil-free lubrication for eliminating oil from steam cylinders. Exhaust steam and condensate are rendered entirely free from oil and can be used for direct process work or boiler feeding.

Department of Scientific and Industrial Research.

Exhibits by the Fuel Research Station, the Mechanical Engineering Research Laboratory, the National Physical Laboratory, Torry Research Station, the British Cast Iron Research Station, the British Hydromechanics Research Association and Pametrada are featured on the stand of the Department of Scientific and Industrial Research. The main exhibit by the Fuel Research Station is a small experimental plant employed in connection with a pilot plant in operation at Greenwich for the synthesis of liquid fuels and chemical products from coal by the Fischer-Tropsch process, in which the products are formed by the chemical reaction of carbon monoxide and hydrogen in the presence of a solid catalyst; the plant on view employs a liquid-phase technique for carrying out and controlling the reaction. A further note on this subject appears elsewhere in this issue.

Among the exhibits of the Mechanical Engineering Research Laboratory, which are primarily concerned with extrusion research and the application of physical techniques to engineering research, may be mentioned equipment for the dynamic calibration of direct-stress fatigue-testing machines, employing a battery-operated resistance strain-gauge bridge circuit, which is simple to control, eliminates the need for a low-distortion oscillator and output transformer to drive the bridge, and does not require any form of phase-sensitive detection. Some of the work of the Laboratory on fretting corrosion was described on page 305 of our 175th volume (March 6, 1953). The equipment used in these studies is on view, including a new technique for observing the emission of charged particles from freshly-worn surfaces.

The N.P.L. exhibit illustrates some of their work on the brittle fracture of mild steel—a phenomenon which has led to several catastrophic failures in welded structures. Working on iron of high purity and alloys made from it, the N.P.L. have determined that the transition temperature below which brittle fractures can occur under certain stress conditions is greatly affected by very small percentages of oxygen, carbon or nitrogen; such effects depend also on the heat treatment. The addition of most metallic elements in amounts up to 5 per cent. has, however, a comparatively small effect on the transition temperature; an exception is manganese, which has a beneficial effect.

ENGINEERING, MARINE AND WELDING EXHIBITION.

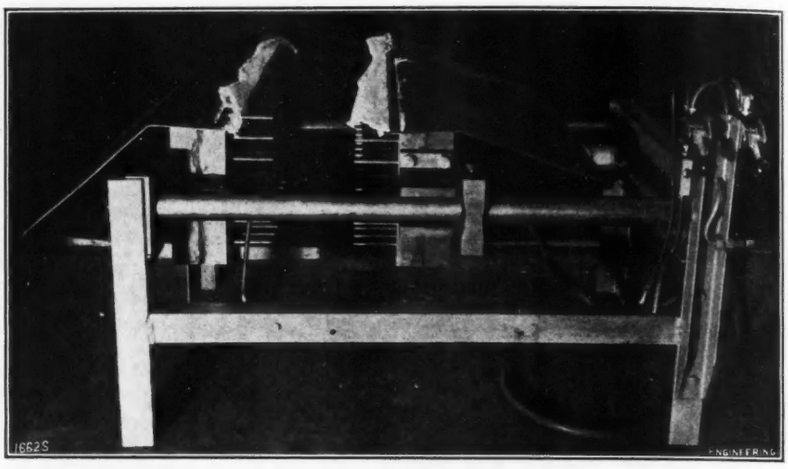


Fig. 67. Pneumatic Clamp with Shell Mould, in Open Position; British Cast Iron Research Association.

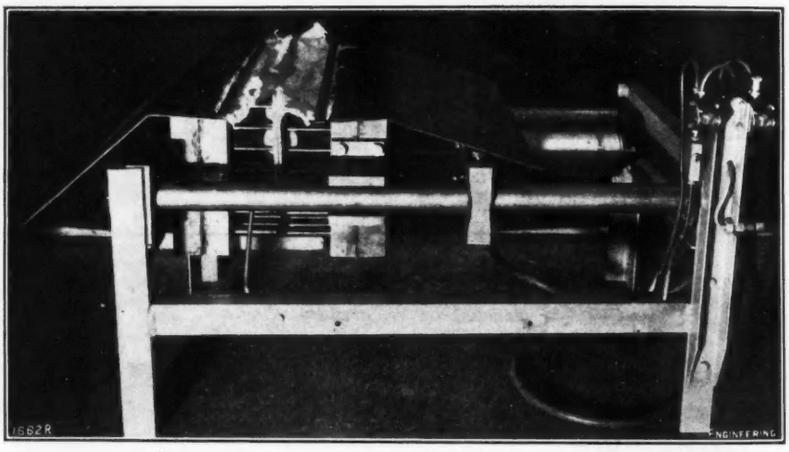


Fig. 68. Clamp in Closed Position; B.C.I.R.A.

Pneumatic Clamp for Shell Moulds.

Among the exhibits displayed by the British Cast Iron Research Association on the D.S.I.R. stand are experimental moisture and permeability testers for investigations on the properties of moulding sands; an improved exhaust arrangement for foundry pedestal grinders; and a pneumatic clamp, shown in Figs. 67 and 68, above, for use in the shell-moulding process. This clamp, which has been developed for vertically-cast moulds, holds the shell mould uniformly over the whole area, thus preventing the shell from warping during cooling and resulting in less flash on the casting.

The clamp consists of a regular arrangement of steel pins sliding freely in the facing inner walls (which are sufficiently thick to provide an adequate bearing length for the pins) of two hollow boxes connected, through a common restrictor valve, to a compressed-air supply. One box is fixed; the other, connected to a piston in a compressed-air cylinder, can be moved relative to the fixed box. When setting up the mould, the movable box is shifted forward with the pins retracted. The complete shell mould is set between the opposing pins, and air pressure is admitted to the two hollow boxes, causing the pins to move forward, at a rate controlled by the restrictor valve, to conform to the contour of the shell; each pin exerts the same thrust on the shell and the two halves are held firmly together for pouring. After the casting has solidified, the air pressure is released and the movable box is withdrawn, allowing the mould and casting to drop away.

Feeder for Hydraulic Transport of Coal.

The British Hydromechanics Research Association are demonstrating, on the stand of the Department of Scientific and Industrial Research, a transparent working model of a mechanical coal feeder for an installation for transporting coal by water under high pressure through a pipeline from the mine to the surface This method of transportation is often preferable to mechanical conveying in mines where there are frequent changes in elevation or direction. The feeder on view has been developed in the course of a general study of the mechanics of hydraulic conveying, which covers various practical aspects in addition to fundamental problems, such as the relation of pressure drop to solids concentration, size and density, pipe size, and velocity in horizontal, sloping and vertical pipes.

A diagram of the double-acting reciprocating feeder developed by the Association for introducing solids into a high-pressure water pipeline is given in Figs. 69 and 70, opposite. It consists of a plunger containing two chambers which reverses automatically, so that at one end of its stroke one chamber lies beneath the hopper and receives coal, while the other chamber is opposite one branch of the pressure pipeline into which its load of coal is discharged. The water pressures on the plunger are balanced and the power required to reciprocate

ENGINEERING, MARINE AND WELDING EXHIBITION.

Fig. 69.

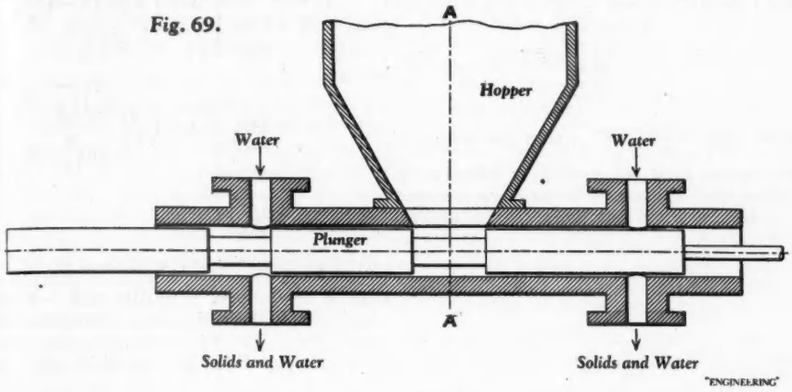
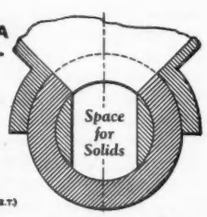


Fig. 70.
SECTION A-A (ENLARGED).



FIGS. 69 AND 70. FEEDER FOR HYDRAULIC TRANSPORT OF COAL; BRITISH HYDROMECHANICS RESEARCH ASSOCIATION.

the plunger is, therefore, only that necessary to overcome mechanical friction. Power is also required to return to the high-pressure line the volume of water withdrawn by the plunger chambers. The model on view, which is capable of handling 10 cwt. of coal and 400 gallons of water per hour, has pipelines of ¾-in. bore; the feeder plunger is 1½ in. in diameter.

A full-scale installation with a 14-in. or 16-in. diameter pipeline and an 18-in. diameter feeder could handle 400 tons of coal per hour up to about 5 in. or 6 in. in size (about one-third of the pipe diameter), absorbing a total power of about 1,600 h.p. for a 2,000-ft. lift; this figure, it is claimed, compares favourably with the power required by conventional winding engines; installations of this type also have the advantage that output can be increased, without the need for a costly new shaft, by fitting additional pipelines in the shaft or by sinking relatively cheap boreholes near the coal face.

GUARDING VALVE FOR SENSITIVE VACUUM GAUGE.

On the stand of the Department of Scientific and Industrial Research, Pametrada are showing a model of a geared marine steam unit developing 8,250 shaft horse-power, in which high-pressure and low-pressure ahead and astern turbines drive the propeller shaft through articulated double-reduction gearing. The unit operates at a steam pressure of 500 lb. per square inch and a temperature of 800 deg. F.; the propeller speed is 103 r.p.m. They are demonstrating methods for analysing noise and vibration in rotating machinery, and a purity-sampling unit for taking steam samples from turbine machinery and analysing them for gaseous impurities. They are also showing examples of their basic research work and full-scale tests on gearing, and a new design of impulse-turbine diaphragm, stronger and less costly than all-machined diaphragms, in which the nozzle segments are formed from standard rolled strip and spacers.

A new guarding valve designed by Pametrada, and shown in Fig. 71, above, enables a sensitive vacuum gauge to be fitted to a turbine astern-nozzle box and protected automatically when positive astern steam pressure is applied. The fitting of a sensitive vacuum gauge to the astern nozzle box of a marine steam turbine (in which astern turbines are usually incorporated with the ahead units) enables any leakage of steam pressure past the astern control

Fig. 71.

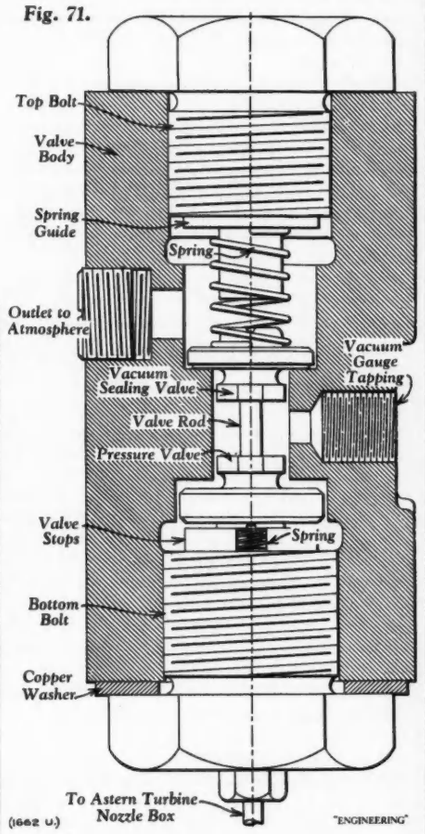


FIG. 71. GUARDING VALVE FOR SENSITIVE VACUUM GAUGE; PAMETRADA.

valve to be detected conveniently. Such leakages can cause appreciable overheating and loss of power. For example, a leakage amounting to 1 per cent. of the full-power steam flow may reduce the ahead power by 3 per cent. or more. It is, however, essential to protect the vacuum gauge from damage when astern steam pressure is applied. The new guarding valve carries out this function as follows: when running ahead, a spring-loaded vacuum sealing valve is held on its seat, and the sensitive vacuum gauge is in direct communication with the astern nozzle box. When the astern control valve is opened, at a predetermined pressure (approximately 1 lb. per square inch gauge) the vacuum sealing valve lifts from its seat, allowing a small temporary flow of steam past the pressure valve. The latter is fitted with a clearance plunger portion and is larger in diameter than the vacuum-sealing valve; the valve assembly therefore moves up rapidly until the pressure valve seats. The gauge is then vented to atmosphere through the vacuum valve, and is isolated from the astern nozzle box by the pressure valve. The valve assembly is designed to be unstable so that the change-over point is consistent and operation is instantaneous.

(To be continued.)

DEVELOPMENTS IN THE FISCHER-TROPSCH PROCESS.

As we have emphasised on a number of occasions in the past, the operation of the Fischer-Tropsch process to produce petrol, Diesel oil and other liquid fuels as main products is not commercially economic in this country or in the United States, at the present prices of coal relative to petroleum oil. Where very cheap coal is available, however, the production of synthetic oil can compete with imported petroleum and, at the present time, a Fischer-Tropsch plant, to produce about 200,000 tons per annum of petrol, Diesel oil, and waxes from low-grade coal is in course of construction at Coalbrook, Orange Free State, Union of South Africa. Serious consideration has been given to the erection of a similar plant in Southern Rhodesia, where similar conditions prevail. Moreover, the possibilities of combining oil synthesis with other processes, such as town-gas manufacture, electricity generation, pig-iron production, or the manufacture of calcium carbide merit examination and the production of high-melting-point waxes or oxygenated products by Fisch-Tropsch synthesis might well prove to be economic.

Considerable advances have been made on the chemical-engineering side of the process. The synthesis reaction is strongly exothemic, 7,000 B.Th.U. being released for every pound of product made, and the formation of the required products is dependent to a great extent on the efficient control of the temperature of the catalyst employed by the removal of the heat of reaction. By utilising the "fluidised-solids" technique for the synthesis, very much higher rates of heat transfer from the powdered catalyst to the cooling water can be obtained. The fluidised-catalyst system, however, suffers from the disadvantage of requiring a somewhat narrow range of conditions for successful operation and is, in any case, restricted to the production of gaseous and low boiling-point hydrocarbons of the petrol type and oxygenated compounds of low-molecular-weight. Various liquid-phase systems have been tried out in the Fischer-Tropsch process. In these, the catalyst is in direct contact with a non-volatile liquid cooling medium and although the presence of this medium retards the rate of the synthesis reaction, very efficient cooling of individual catalyst particles is obtained and the production of undesired substances, such as methane, is minimised.

The Fuel Research Station of the Department of Scientific and Industrial Research, River-way, Blackwall-lane, East Greenwich, London, S.E.10, has carried out research and development work on the Fischer-Tropsch process since 1935. From this work it appears that the most promising of the liquid-phase techniques is the "slurry" process in which a finely-powdered catalyst is suspended in molten wax and the synthesis gas is passed up through the suspension. Volatile reaction products pass out of the reactor with the effluent gas stream; non-volatile waxes and heavy oil remain in the slurry, whence they are removed through a filter to maintain a constant level of liquid in the reactor. For the study and development of process techniques two laboratory-scale fluidised-catalyst units and four liquid-phase units are available at the Fuel Research Station. One of the liquid-phase units is now in operation on the stand of the Department of Scientific and Industrial Research at the Engineering, Marine and Welding Exhibition at Olympia. To obtain more reliable chemical-engineering data for various reaction systems and to facilitate the design of a suitable reactor for commercial-scale operation, a pilot-plant to yield from 50 to 60 gallons of products a day has been built at the Research Station. This plant has been equipped with two reaction vessels, one designed for a fluidised catalyst and the other for the slurry process.

WEBB'S APPROXIMATION FOR SEC θ.

By T. A. S. JACKSON, Ph.D., L. ROSENHEAD, F.R.S., and T. MURPHY, B.Sc.

THE approximate equivalence for the bowed shape and for the eccentricity of loading of a pin-jointed strut is generally obtained by using Webb's approximation for sec θ. The approximation makes it possible to demonstrate the similarities between the Perry-Robertson type of strut formula (based on initial crookedness) and the Smith-Southwell type of secant formula (based on eccentricity of loading). The solution of the secant equation for allowable stresses in an eccentrically loaded strut is also facilitated by the use of the approximation. The approximation is therefore of some importance but Webb's own derivation does not appear to be available. The following alternative means of derivation, together with a discussion of the accuracy of the approximation, has been developed by the authors, working in the Applied Mathematics Department of the University of Liverpool in conjunction with Professor J. B. B. Owen, D.Sc., Professor of Civil Engineering at the University.

Webb's approximation for sec θ is given by

$$\sec\theta \approx \frac{1+0\cdot26\left(\frac{2\theta}{\pi}\right)}{1-\left(\frac{2\theta}{\pi}\right)^2} \equiv F_1(\theta), \quad . \quad (1)$$

and it has been stated by Case* that the formula is correct to within $\frac{1}{2}$ per cent. for all values of θ between 0 and $\frac{\pi}{2}$.

If Webb's approximation is valid in the range 0 to $\frac{\pi}{2}$ it must also be valid in the range 0 to $-\frac{\pi}{2}$, for sec θ is an even function of θ. Further, since sec θ has simple infinities at $\theta = \pm\frac{\pi}{2}, \pm\frac{3\pi}{2}, \ldots$ the following formula seems not unreasonable:—

$$\sec\theta = \frac{f(\theta)}{1-\left(\frac{2\theta}{\pi}\right)^2}, \quad . \quad . \quad (2)$$

where $f(\theta)$ will be continuous for all values of θ in the range $-\frac{3\pi}{2} < \theta < \frac{3\pi}{2}$. The problem now resolves itself into that of finding a convenient representation for $f(\theta)$. For a sufficiently small region about $\theta = 0$, it is natural to take the first few terms of the Maclaurin series. Thus,

$$f(\theta) = \left\{1-\left(\frac{2\theta}{\pi}\right)^2\right\}\left[1+\tfrac{1}{2}\theta^2+\frac{5}{24}\theta^4+\ldots\right]$$

$$= 1+\left\{\frac{\pi^2}{8}-1\right\}\left(\frac{2\theta}{\pi}\right)^2+ \frac{\pi^2}{8}\left\{\frac{5\pi^2}{48}-1\right\}\left(\frac{2\theta}{\pi}\right)^4+\ldots$$

$$\approx 1+0\cdot2337\left(\frac{2\theta}{\pi}\right)^2+0\cdot0346\left(\frac{2\theta}{\pi}\right)^4\ldots \quad (3)$$

This suggests the following approximation,

$$\sec\theta \approx \frac{1+0\cdot2337\left(\frac{2\theta}{\pi}\right)^2}{1-\left(\frac{2\theta}{\pi}\right)^2} \equiv F_2(\theta) \quad . \quad (4)$$

For a range of θ rather more wide than the one for which equation (3) is valid, and if only two terms are to be kept in $f(\theta)$, it will be advantageous to modify slightly the coefficient, 0·2337, which occurs in equation (4). This has been done by Webb, presumably in an empirical way.

* J. Case, *Strength of Materials*, page 294, E. Arnold and Company, Reprint 1948.

If it be assumed that an approximate formula for sec θ may be written in the form

$$\sec\theta \approx \frac{1+A\left(\frac{2\theta}{\pi}\right)^2}{1-\left(\frac{2\theta}{\pi}\right)^2} \equiv F(\theta), \quad . \quad (5)$$

in the range $-\frac{\pi}{2} \leqslant 0 \leqslant \frac{\pi}{2}$, then the method of least squares gives A = 0·2565, as follows: the required value of A is that which reduces to a minimum the integrated square of the proportional errors, that is,

$$\int_0^{\frac{\pi}{2}}\left(\frac{F(\theta)-\sec\theta}{\sec\theta}\right)^2 d\theta, \quad . \quad . \quad (6)$$

is to be a minimum. The integrations have been carried out numerically using Simpson's formula (1, 4, 2, 4, . . . 2, 4, 1) and intervals of θ equal to $\frac{1}{50}\left(\frac{\pi}{2}\right)$; this method gives A = 0·2565.

Three approximations are now available, namely,

(*a*) The Webb formula:

$$\sec\theta \approx \frac{1+0\cdot26\left(\frac{2\theta}{\pi}\right)^2}{1-\left(\frac{2\theta}{\pi}\right)^2} \equiv F_1(\theta)$$

(*b*) The Maclaurin formula:

$$\sec\theta \approx \frac{1+0\cdot2337\left(\frac{2\theta}{\pi}\right)^2}{1-\left(\frac{2\theta}{\pi}\right)^2} \equiv F_2(\theta)$$

(*c*) The Least Squares formula:

$$\sec\theta \approx \frac{1+0\cdot2565\left(\frac{2\theta}{\pi}\right)^2}{1-\left(\frac{2\theta}{\pi}\right)^2} \equiv F_3(\theta) \quad . \quad (7)$$

These three functions, together with sec θ, are given numerically in the Table, herewith; in addition, the proportional error introduced by replacing sec θ by either $F_1(\theta)$, $F_2(\theta)$ or $F_3(\theta)$ is given in columns 6, 7 and 8 of the Table, respectively. The last entries in these columns are:

$$\lim_{\theta\to\frac{\pi}{2}}\left\{\frac{F_r(\theta)-\sec\theta}{\sec\theta}\right\} \text{ for } r = 1, 2 \text{ or } 3,$$

$$= \lim_{\theta\to\frac{\pi}{2}}\left\{\frac{1+A_r\left(\frac{2\theta}{\pi}\right)^2}{1-\left(\frac{2\theta}{\pi}\right)^2\sec\theta}-1\right\},$$

where A_r, for $r = 1, 2$ and 3, denotes the coefficient which occurs in the Webb, Maclaurin, or Least Squares formula, respectively. Now, according to equation (2),

$$\left\{1-\left(\frac{2\theta}{\pi}\right)^2\right\}\sec\theta = f(\theta),$$

and

$$\lim_{\theta\to\frac{\pi}{2}} f(\theta) = \lim_{\theta\to\frac{\pi}{2}}\left[\frac{\left\{1+\left(\frac{2\theta}{\pi}\right)\right\}\left\{1-\left(\frac{2\theta}{\pi}\right)\right\}}{\cos\theta}\right]$$

$$= \lim_{\theta\to\frac{\pi}{2}}\left[\left(1+\left(\frac{2\theta}{\pi}\right)\frac{\left(\frac{2}{\pi}\right)\left(\frac{\pi}{2}-\theta\right)}{\sin\left(\frac{\pi}{2}-\theta\right)}\right)\right]$$

$$= 2\left(\frac{2}{\pi}\right)1 = \frac{4}{\pi}.$$

The required entries are, therefore, $(1+A_r)\frac{\pi}{4}-1$, that is, −0·01040, −0·03105 and −0·01315, for the Webb, Maclaurin and Least Squares formula, respectively. The error introduced by replacing sec θ by either $F_1(\theta)$, $F_2(\theta)$ or $F_3(\theta)$ can be seen by comparing columns 6, 7 and 8 of the Table.

TABLE I.

1.	2.	3.	4.	5.	6.	7.	8.
$\frac{2\theta}{\pi}$	Sec θ.	$F_1(\theta)$.	$F_2(\theta)$.	$F_3(\theta)$.	$\frac{F_1(\theta)-\sec\theta}{\sec\theta}$	$\frac{F_2(\theta)-\sec\theta}{\sec\theta}$	$\frac{F_3(\theta)-\sec\theta}{\sec\theta}$
0·00	1·0000000	1·0000000	1·0000000	1·0000000	0·00000	0·00000	0·00000
0·10	1·0124651	1·0127273	1·0124616	1·0126919	+0·00026	−0·00000$_5$	+0·00022
0·20	1·0514622	1·0525000	1·0514042	1·0523542	+0·00099	−0·00006	+0·00085
0·30	1·1223262	1·1246154	1·1220143	1·1242692	+0·00204	−0·00028	+0·00173
0·40	1·2360680	1·2400000	1·2349035	1·2393333	+0·00318	−0·00087	+0·00264
0·50	1·4142136	1·4200000	1·4112333	1·4188333	+0·00409	−0·00211	+0·00327
0·60	1·7013016	1·7087500	1·6939562	1·7067812	+0·00438	−0·00432	+0·00322
0·70	2·2026893	2·2105882	2·1853196	2·2072255	+0·00359	−0·00789	+0·00206
0·80	3·2360680	3·2400000	3·1932444	3·2337778	+0·00122	−0·01323	−0·00071
0·90	6·3924532	6·3715789	6·2594579	6·3566579	−0·00327	−0·02080	−0·00504
0·92	7·9787298	7·9431250	7·7926906	7·9238385	−0·00446	−0·02332	−0·00688
0·93	9·1129200	9·0664249	8·8980543	9·0440181	−0·00510	−0·02358	−0·00756
1·00	∞	∞	∞	∞	−0·01040	−0·03105	−0·01315

It is concluded that the coefficient, 0·26 in Webb's formula, agrees to two significant figures with the value obtained by the least-squares method; in addition, Webb's formula has a smaller maximum modulus of error than the Least-Squares formula. It is concluded also that the statement made earlier about the accuracy of Webb's formula is in error. The formula is accurate to within $\frac{1}{2}$ per cent. only in the range 0 to 93 grades (approximately 83$\frac{1}{2}$ deg.; 1 grade = $\frac{\pi}{200}$ rad.); as θ approaches $\frac{\pi}{2}$ the percentage error approaches 1.

LONDON ON WHEELS EXHIBITION EXTENDED.—The British Transport Commission announce that the "London on Wheels" Exhibition at the Shareholders' Meeting Room, Euston Station, London, N.W.1, which was described in our issue of May 29 (vol. 175 page 691) is to be extended until January 30, 1954. Admission fees have been reduced to sixpence for adults and threepence for children.

AN IMPROVED SHEET MATERIAL FOR HIGH-TEMPERATURE USES.—For many years the high-strength high-temperature alloy developed under the name of Nimonic 75 has been widely used in sheet form for the combustion-chamber linings in many British gas turbines. In this type of service the chief requirements of the metal, in addition to high resistance to scaling, are strength to resist distortion and cracking through the stresses arising from thermal expansion. Nimonic 75 fulfils these needs to an adequate degree and, in addition, readily lends itself to normal fabricating, including argon-arc and resistance welding. For some time, work has been going on to develop a material which would have the characteristic properties of Nimonic 75 but, at the same time, would have a much higher heat conductivity in order to dissipate the heat of the combustion in the chamber more quickly and secure more even temperature distribution in the chamber. Under the registered trade mark, "Nimoply 75," Henry Wiggin & Co. Ltd., Wiggin-street, Birmingham, 16, now announce the introduction of composite metal sheets, having Nimonic 75 on both sides of a copper base. This metal "sandwich" is produced by rolling copper between sheets of Nimonic 75, resulting in a "clad" sheet having many potential uses, not only in gas-turbine construction but also in other fields of high-temperature engineering.

THE MILLING OF RAIL ENDS AND ITS EFFECT ON PRODUCTIVITY.

By SIR CHARLES F. GOODEVE, O.B.E., F.R.S.*

IN seeking methods of improving productivity in British steelworks, the Iron and Steel Productivity Team reported† that "The majority of American rails are delivered with relatively accurate hot-sawn ends, a practice which is not permitted by the British specification. The allowable tolerance on length is $\pm\frac{1}{16}$ in., which is similar to British practice, and only rails outside this tolerance are milled. This amounts to about 10 per cent. of the total output. Such a practice gives the American producers a definite advantage, and it is suggested that the necessity for milling the entire output of British rails should be examined." This examination has now been carried out, and leads to the conclusion that the British practice gives a much better product, with no appreciable loss in productivity.

The British Standards Institution specifications‡ require that "All rails shall have their ends sawn or machined true and square. All burrs shall be removed before despatch from the manufacturer's works"; and "The rails shall be the specified length at a temperature of 62 deg. F. Any rail may be rejected which is more than $\frac{1}{16}$ of an inch above or below the length specified at that temperature, whether for straight or curved line." In the early part of this century, British practice on the treatment of rail ends was similar to that now carried out in America. However, in order to improve the quality of the product, present British practice is based on a general agreement reached after the first World War, under which hot sawing is not used as the finishing process.

Most American rails are manufactured to specifications of either the American Railway Engineering Association or the American Society for Testing Materials, which include clauses to the effect that "Rails must be sawed square at the ends, with an allowable variation of not more than $\frac{1}{16}$ in. out of square in any direction, except that $\frac{3}{64}$ in. is permitted for 155 lb. per yard rails. Burrs are entirely removed . . ."; and that, "For 39-ft. rails, a variation in length of $\frac{3}{8}$ in. is permitted, except that, on 15 per cent. of an order, a variation of $\frac{7}{16}$ in. is permitted. For 33-ft. rails, a variation of $\frac{1}{4}$ in. is permitted, except that, on 15 per cent. of an order, a variation of $\frac{3}{8}$ in. is allowed. . . . Length tolerances for any length of rail are based on measurements at approximately 60 deg. F." For rails 39 ft. in length, these tolerances are twice those quoted in the Report, and it is understood that they are worked to and readily achieved by hot sawing. The British length tolerance of $\pm\frac{1}{16}$ in. is applied to 60-ft. main-line rails, and, in comparison with the American tolerance of $\pm\frac{3}{8}$ in. to 39 ft., is more than three times closer. On the length aspect alone, the British tolerance would be very difficult to achieve by hot sawing, as a temperature control at the saw within $\pm$20 deg. C. would be necessary.

It might well be asked whether this fine tolerance used in Britain is necessary. The railwayman's viewpoint is that wider tolerances in length would cause difficulties in obtaining "square" joints between the two rails forming the track; this difficulty is not encountered in America, where the joints are staggered. Also, the introduction of prefabricated track by British railways, which has occasioned a significant advance in the speed of laying, would have been difficult unless rails to very close tolerances had been available.

Similar remarks apply to the question of the squareness of the rail end, which is much better, though unspecified, on British rails. If the rail end is cut at an angle in any direction, the normal expansion gap between two adjacent rails cannot be employed, as the gap would have to be provided on the shortest distance between the rails to avoid the risk of buckling. Elsewhere, the gap would be excessive. This is likely to cause rough riding of the trains, with consequent hammering of the wheels on the joints and increased fatigue of the rail ends. It is possible, however, that the importance of square ends is diminished if the practice of welding rails is employed, as in some parts of America. Another advantage of milled ends is that it is easier to detect defects, such as piping, than if the rails are only hot-sawn.

These facts show that the British method achieves a better product. The question whether productivity is lowered requires examination on the basis of the consumption rates of the four main resources, that is, machine time, labour, power, and materials.

All rails require to be drilled on a precision machine. In Britain, such machines incorporate a milling unit which does this operation simultaneously with the drilling, and in the same time. These machines require no more manning than one without the additional ending unit; therefore, except for the initial cost of the additional unit and the labour cost of maintaining cutting edges, etc., there is no loss of productivity on these first two resources, that is, machine time and labour time. Indeed, there are reasons to believe that the American method gives the lower productivity on machine and labour time. Hot-sawn ends might reduce productivity, as the "rag" (or burr) would have to be removed by a subsequent operation. In Britain, the "rag" is removed during milling. Also, it would appear that, in any case, the American rail-makers have to have milling machines, as the Report states that about 10 per cent. of the rails made in the United States are milled, as they are outside the required tolerance. The utilisation of these milling machines will probably be low.

The extra power for machining is very small. No evidence exists as to the yield on the steel that is used, but there is no reason to believe that it should be different between hot-sawn and cold-machined ends. It is considered, therefore, that the British practice of milling the rail end gives a product which is superior in quality to one produced by the method common in the United States, without any appreciable loss in productivity and even, possibly, with a gain. It is understood that Canadian rail-makers have now adopted the British method.

This article is published with the concurrence of the author's colleagues on the British Iron and Steel Productivity Team. He is indebted to Mr. D. A. Winton for the examination described above.

* Director, British Iron and Steel Research Association.

† Productivity Team Report on Iron and Steel. Anglo-American Council on Productivity, page 58.

‡ British Standard Specifications No. 9 (for bull-head rails) and No. 11 (for flat-bottom rails).

CATHODIC PROTECTION OF BURIED OR SUBMERGED STRUCTURES: ERRATUM.—Owing to a typographical error, which we regret occurred on page 287, *ante*, in the 14th line from the end of the article on "Cathodic Protection of Buried or Submerged Structures," the word "now" was altered to "not." The sentence should read ". . . 'Guardion' service, which will now include 'Westalite' cathodic-protection equipment . . ."

COURSES ON PHOTOELASTICITY.—A course of twelve lectures and demonstrations on the practical application of photoelastic methods to the investigation of two-dimensional stress distributions will be delivered at University College London, on Mondays, commencing on October 12, 1953. Another course of twelve lectures and demonstrations, on recent developments in the photoelastic investigation of three-dimensional stress problems, will be delivered at the College, also on Mondays, commencing on February 1, 1954. Each session at both courses will begin at 2 p.m. and last for one hour. The fee for each course will be 7*l.* 17*s.* 6*d.* Further particulars may be obtained from the secretary, University College London, Gower-street, W.C.1.

AUTOMATIC RADAR METEOROLOGICAL STATION.

WHAT we understand is the first automatic station for observing and recording weather conditions in the upper air has been erected at Pease Pottage, near Crawley, Sussex, and the equipment is now being installed. This station will form part of a network of eight upper-air meteorological stations that have been set up in this country during recent years and will also link up with a similar network of stations in Western Europe and thence with other stations throughout the world. Experimental operation of the Crawley station for the precise computation of wind conditions in the upper air is expected to commence in October next and it is anticipated that the station will be ready for automatic observations of temperature, pressure and humidity early in 1954. The meteorological readings will then be sent by teleprinters, in the form of numerically coded weather reports, to the Central Meteorological Office at Dunstable and will there be used, together with similar reports obtained from many other meteorological observing centres, for all kinds of weather forecasting, particularly that required for air lines operating high-speed aircraft flying at high altitudes.

The need for improved meteorological services covering greater heights will be apparent when it is pointed out that the average ceiling height for civil aircraft, which was 12,000 ft. in 1944, had increased to 23,000 ft. by 1950, while at the present time jet aircraft, such as the Comets, are carrying out normal flights at heights up to 40,000 ft. These rapid developments have brought into prominence the need for a completely automatic meteorological system capable of providing accurate information regarding wind speed and direction over a range of at least 100 nautical miles from the observing station and also of transmitting sonde information, i.e., data of air temperature, pressure and humidity, to the ground with greater accuracy than has hitherto been attained.

The new equipment now being installed at the Crawley station has been specifically designed to meet these requirements. It has been developed and constructed for the British Meteorological Office by Mullards, Limited, Century House, Shaftesbury-avenue, London, W.C.2, and is based on research work undertaken by the Telecommunications Research Establishment of the Ministry of Supply at Malvern, who have also collaborated in carrying out the project. The new system is known as "radar sonde," as distinct from the well-known "radio sonde" system, and, as will be inferred from its name, employs radar technique in place of radio. Briefly, an automatic radar transmitting and receiving station on the ground works in conjunction with a small receiving and transmitting set attached to the hydrogen-filled balloon. These small airborne sets are known as "transponders." Two types of transponder are employed: one for wind measurements only and the other providing sonde information in addition. Balloons carrying a transponder are released from the ground station at certain internationally agreed times and as the balloon ascends its transponder receives "interrogating" radar pulses of 2 micro-seconds duration from the ground transmitter, which has a peak capacity of 50 kW and operates at a frequency of 152·5 megacycles per second. The interrogating pulses cause the airborne transmitter to send back pulses to the ground station on a secondary frequency of 2,850 megacycles per second (10 cm. wavelength). They are received on a paraboloidal aerial, provided with an electronic device at the focus, which keeps the aerial unit always directed towards the balloon. The slant range of the airborne unit, i.e., the distance in a straight line between the ground station and the balloon, is measured by determining the time interval between the transmitted and received pulses. From this, and from the measured angles of the aerial unit in elevation and azimuth, the drift of the balloon in space can be computed. Wind speed and direction are computed automatically and continuously from the rates of change of the measured parameters.

AUTOMATIC RADAR METEOROLOGICAL STATION.

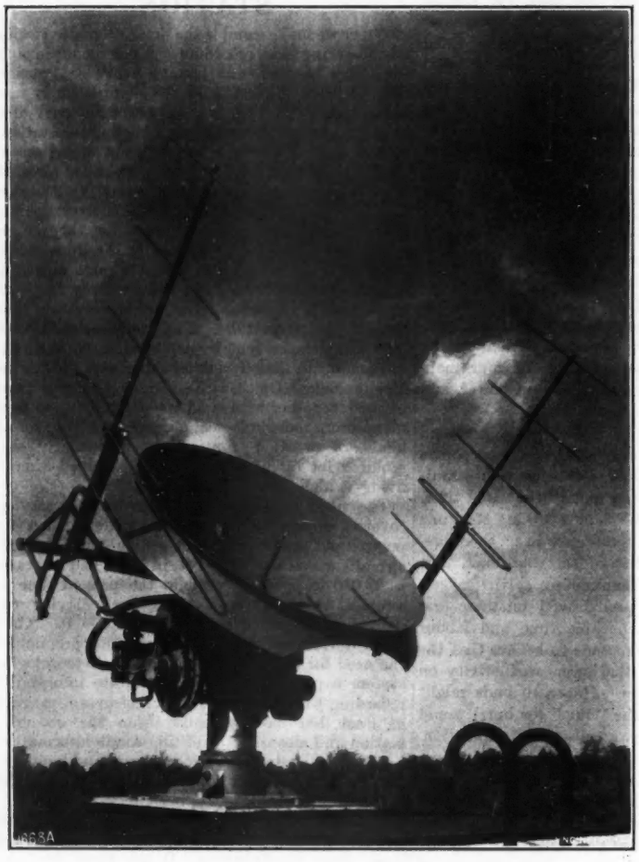


FIG. 1. SELF-ALIGNING AERIAL UNIT AT GROUND STATION.

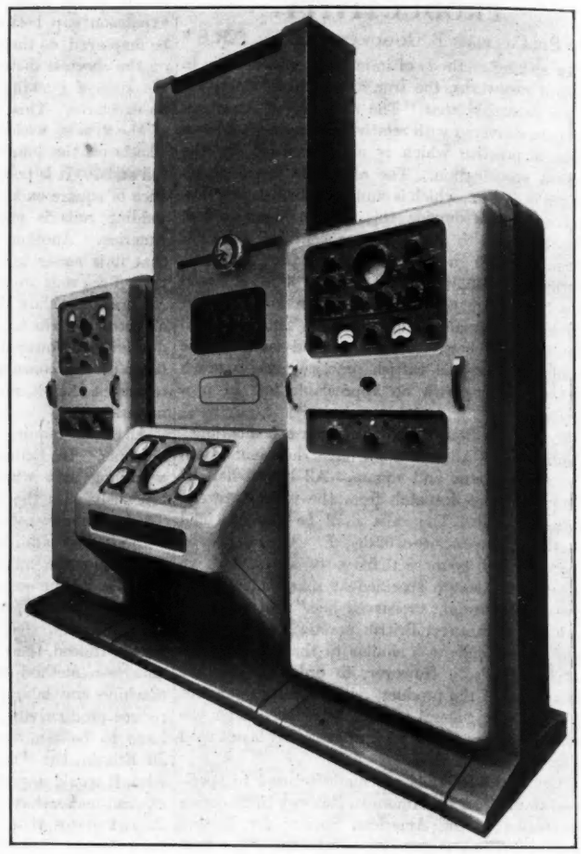


FIG. 2. TRANSMITTER-RECEIVER AND DISPLAY UNIT.

The height of the balloon is also computed and a correction for the curvature of the earth is applied automatically.

The telemetering of data on temperature, pressure and humidity, registered by the meteorological elements in the sonde unit, is effected by causing the airborne transmitter to send out twin pulses each time the sonde is interrogated from the ground, the separation between the twin pulses serving as a measure of the reading of the particular meteorological element in circuit at the time. The three elements are switched into the telemetering circuit in sequence by a motor-driven switch. In this way a complete cycle of sonde readings is telemetered to the ground station every 15 seconds during the flight of the balloon. A fourth element is included in the cycle to provide a constant reference reading, so that any change in the telemetering circuits affecting the accuracy of the meteorological readings will be apparent by a change in the reference reading. When the balloon bursts on reaching its maximum altitude of up to 100,000 ft. a parchute opens and the transponder unit slowly descends. During the descent the airborne unit continues to be interrogated by the ground station.

Only a brief description of the electronic equipment is possible in the space at our disposal, but some general particulars may be of interest. The aerial unit, of which a photograph is reproduced in Fig. 1, on this page, comprises transmitting and receiving aerials mounted on a common pedestal on the roof of the ground station. The transmitter radiates through a pair of vertically-polarised Yagi arrays mounted on opposite sides of a receiving paraboloid 5 ft. in diameter at the focus of which is a nutating dipole which provides a conical scan. Misalignment of the aerial causes amplitude modulation of the incoming signal at the coning frequency and the error signal thus produced is fed to a servo system which corrects the alignment of the aerial. The equipment in the operations room may be broadly divided into two sections, namely, the radar equipment and the computing and recording equipment. The former comprises a very high-frequency transmitter, a microwave receiver, a display unit and a control column. The transmitter and receiver are built into 6-ft. consoles and form the left-hand and right-hand sections of the four-unit console illustrated in Fig. 2, on this page. The display unit is located between them and houses the range display oscilloscope and the aerial azimuth and elevation repeater magslips. The control column extends from the top of the display unit to the ceiling and carries the controls and indicator lamps for the main power supplies. The computing and recording equipment includes a wind computer and a three-unit console, illustrated in Fig. 3, page 304, comprising a wind recorder, a telemetering unit and a sonde recorder. The wind computer, shown in Fig. 4, page 304, is a separate unit built round a rotatable table 3 ft. in diameter and the computed wind direction is recorded on a polar chart fixed to the table. The wind-recorder unit, on the left in Fig. 3, houses the wind-speed and true-height pen recorders. The central desk unit of the console houses the teleprinter and the telemetering circuits, while the unit on the right is the sonde recorder for the pressure, temperature and humidity elements.

The airborne units, two of which may be released every day in normal operation and many of them are not recovered, have been designed for economic mass production. The radar wind unit comprises a receiver which triggers a transmitter, as previously mentioned, and the sonde unit contains, in addition, the three meteorological elements for measuring pressure, temperature and humidity. Fig. 5, on page 304, shows the airborne wind unit, with its cover removed, and Fig. 6 illustrates the three meteorological elements used in the sonde unit. The pressure unit, on the left, contains an aneroid capsule which operates a movable core in a coil and the electrical signal for humidity is obtained from the central element operated by goldbeaters' skin. The element on the right in Fig. 6 is a wire-resistance type thermometer, designed to give a small time constant and a low radiation constant. For both types of airborne unit, power is obtained from 6·5-volt, 2·5-ampere batteries, a vibrator being used for the high-tension supply. The units are enclosed in a light thermally-insulating container and are suspended from the balloon by a conducting cord which forms a quarter-wavelength receiving aerial. The transmitting aerial projects from the bottom of the container; the peak power output of the transmitter is 30 watts.

The ground equipment gives permanent records automatically on strip recorders of wind speed, balloon height, and temperature, pressure and humidity, the last three quantities being also recorded in four-digit numbers on teleprinter tape. Visual readings of bearing are shown on fine and coarse magslip indicators; the range is shown by a pulse display on a cathode-ray tube. The temperature measurements cover a range from 110 deg. to — 150 deg. F. and are accurate to within half a degree. The pressure range is from 30 to 1,050 millibars and the lower pressures are accurate to one millibar; pressures exceeding 300 millibars are accurate to two millibars. Humidity measurements cover a range from zero to 100 per cent. relative humidity and are accurate within one per cent. The overall accuracy of the system is, of course, limited by that of the meteorological elements, but the equipment is designed to accommodate meteorological units of greater accuracy than are at present available.

INSPECTION LAUNCH FOR THE ROYAL CEYLON NAVY.

JOHN I. THORNYCROFT & CO., LTD., HAMPTON-ON-THAMES.

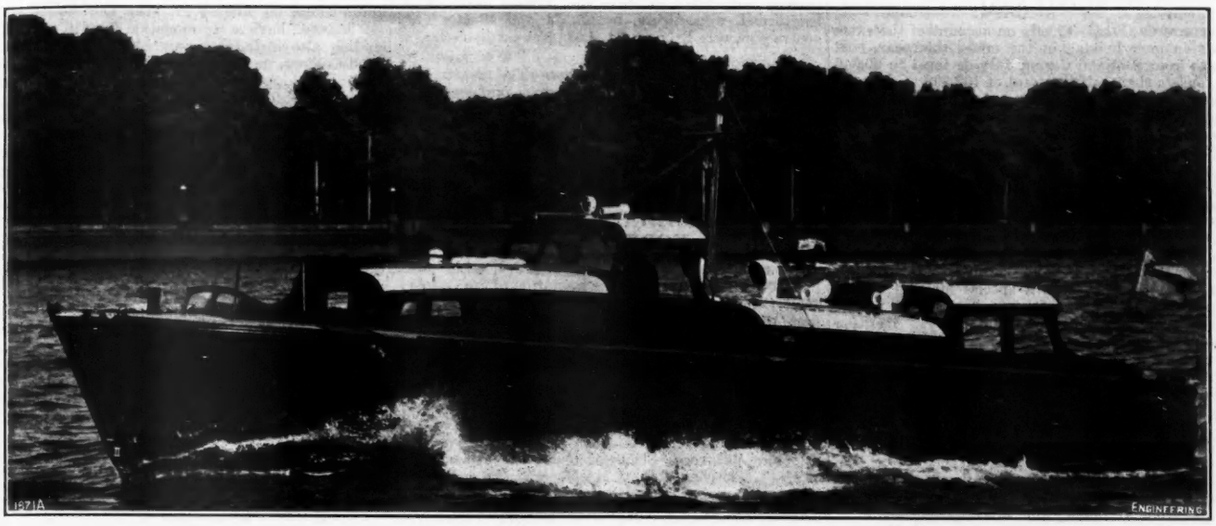


FIG. 1. MOTOR LAUNCH ON THE RIVER THAMES.

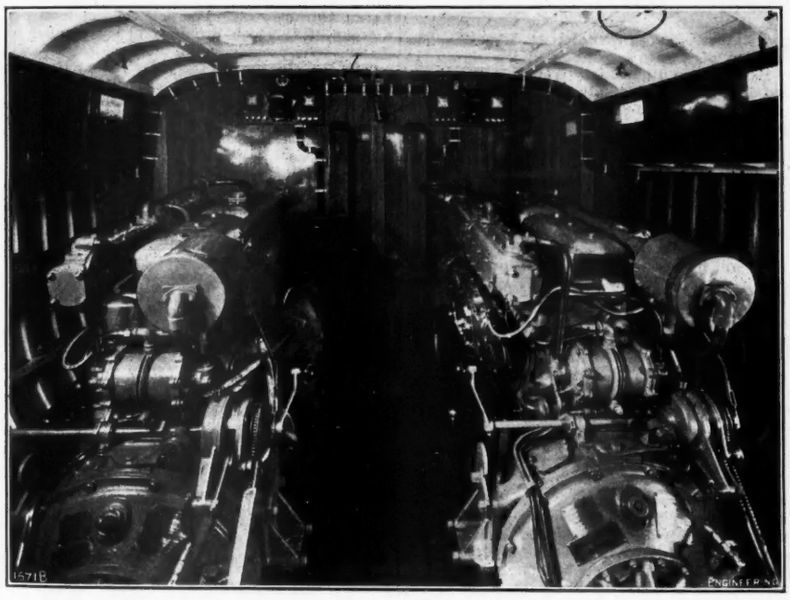


FIG. 2. ENGINE ROOM.

INSPECTION LAUNCH FOR THE ROYAL CEYLON NAVY.

WE illustrate herewith, in Figs. 1 and 2, a twin-screw motor launch recently constructed by Messrs. J. I. Thornycroft, Limited, at their Hampton-on-Thames yard, for the use of senior officers of the Royal Ceylon Navy in carrying out inspections in the harbours of Ceylon. The vessel has a hull of double-skin teak on a framing of American elm and is sheathed below water with Muntz metal. She measures 45 ft. in length overall, with a beam of 10 ft. 6 in. and a draught of 3 ft. 6 in., and is of round-bilge form, with a raked stem and a curved transom stern. The accommodation consists of a roomy forward cockpit; a forward cabin fitted with settees at the after end and on the port side, a drop-leaf table in the centre, and a sideboard at the forward end; a covered wheelhouse, in which also are the engine controls and a dashboard carrying the engine-revolution indicators, etc.; the engine room; and an after cockpit with seats arranged along each side at the forward end and another seat athwartships against the after bulkhead. There are no seats in the wheelhouse, but there is space for chairs to be placed there, if desired. Access from the wheelhouse to the forward cabin is by a passage on the starboard side; and entry to the engine room is through a sliding door from the after cockpit.

The launch is propelled by two Thornycroft RNR/6 marine Diesel engines, fitted with reverse gears and 2 : 1 reduction gears. The clutches of the reverse gears are actuated by oil pressure. The Thornycroft single-lever controls in the wheelhouse operate both the ahead and astern movements of the engines and also control the engine speed. The handles are so arranged that they can be moved either separately or together by the steersman, using one hand only. The steering wheel is on the port side of the wheelhouse. Engine cooling is by a direct sea-water circulating system, and the exhaust pipes, of reinforced rubber composition, are cooled by water injection. Each engine has a maximum output of 90 brake horse-power, and is designed for continuous running at 1,500 r.p.m., at which speed the vessel made 12¼ knots, as the mean speed over six runs. With the engines running at 1,200 r.p.m., the speed was rather more than 9¾ knots, and at the full speed of the engines, 14¾ knots. The trials were run on the Thames, with the fuel-injection pumps set to suit the climatic conditions then obtaining, but it is stated that an adjustment will be made to the pumps before the launch is shipped to Ceylon, to suit the different conditions there.

RADIO SERVICING CERTIFICATE EXAMINATION.—The Radio Trades Examination Board and City and Guilds of London Institute announce that the 1954 radio-servicing certificate examinations will be held on May 4 and 6 for the written papers and on May 15 for the practical test. The closing date for entries is February 1, 1954, and forms of application and copies of the regulations (which have been modified) may be obtained from the secretary of the Board, 9, Bedford-square, London, W.C.1.

DEVELOPMENTS AT LIME GROVE TELEVISION STUDIOS.—A fourth television studio was opened by the British Broadcasting Corporation at Lime Grove, London, W.12, on Friday, August 21. It measures 70 ft. by 66 ft. and is equipped with apparatus designed specifically for studio use. This apparatus is controlled from separate sound and vision rooms which are built above floor level across one corner of the studio so that the staff have a clear view of the whole area. Four cameras with Image Orthicon pick-up tubes of a type not hitherto used for studio work are available. The illuminators are controlled from a desk on the lighting gallery, which runs round the studio 16 ft. above the floor. Other recent additions comprise a presentation suite to ensure the smooth running of the day's programme and a dubbing suite to provide unusual effects and commentaries.

LIVERPOOL UNIVERSITY EXTENSION COURSE ON THE ELECTRIC ARC.—An advanced course of eight lectures on the theory and applications of the electric arc, intended for graduates, engineers, and persons employed in industrial establishments, or engaged on research work, will be delivered at the University of Liverpool on Tuesdays, beginning on October 13, 1953. The lectures, which will commence at 7 p.m., will be given by Dr. H. Edels, who is engaged on research in these problems and is a lecturer in the University's Department of Electric-Power Engineering. The syllabus will include the electrical, optical, thermal and gaseous properties of the electric arc, and the application of this theoretical and experimental data to a study of the behaviour of arcs occurring in engineering practice. The fee is two guineas. Further particulars may be obtained from the Director of Extra-Mural Studies, 9, Abercromby-square, Liverpool, 7.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

EXPORTS OF COAL.—Chiefly on account of the extra week's summer holiday in the mines this year, coal exports from Scotland during July declined to 60,546 tons, or less than half the total of 102,398 tons in the corresponding month last year. Aggregate shipments since the beginning of the year, however, remained higher at 546,188 tons for the seven months, against 516,831 tons for the corresponding period of 1952.

WATER SUPPLIES AT TWO SCOTTISH TOWNS.—A suggestion that a bore should be sunk near Rothes Colliery to tap underground water resources, as a supplementary water supply for Kirkcaldy, has fallen through because the terms offered by the National Coal Board for the facility were not acceptable to the Town Council, it was stated at a special meeting of the Council on August 25. It was decided to pursue other methods of augmenting the supply. Aberdeen Corporation Streets and Works Committee, also on August 25, approved a layout plan for a new reservoir at Pitfodels. This will have a capacity of 2,750,000 gallons and will cost 195,000*l*., including pumping equipment and mains.

CLOSURE OF SHOTTS GASWORKS.—The gasworks at Shotts, which carbonised about 4,600 tons of coal annually, were closed down on August 24 by the Scottish Gas Board. The town will now be provided with gas from Armadale, nine miles away. Mr. J. S. McLaren, deputy area manager, has said that the centralisation of supplies in Armadale and the closure of the Shotts plant would save considerable overhead expense.

DIFFICULTY OF EXPORTING TO AUSTRALIA.—Mr. S. F. Ferguson, director of the Australian Association of British Manufacturers, addressing the export group of the Edinburgh Chamber of Commerce on August 24, referred to difficulties likely to be found by Scottish exporters to Australia next year. Much would depend, he said, on the result of the inquiries now being undertaken by the Australian Tariff Board on the rates of import duty and by the arbitration court regarding the cost-of-living index and wage rates.

FORESTRY SCHOOL AT PITLOCHRY.—The Forestry Commission have transferred one of their five forestry-training schools from Glentress, Peebles, to Faskally House, Pitlochry. Students will receive their practical training, which extends over two years, in the adjoining woodlands and the neighbouring State forests. Students from all over Scotland and the North of England are taking part in the training scheme.

CLEVELAND AND THE NORTHERN COUNTIES.

INTER-FACTORY VISITS.—The Tyneside Productivity Committee have organised two factory visits as part of their campaign to step-up production. On September 17, six men (two representatives of the management, two technicians and two trade unionists) from the Wallsend works of Victor Products, Ltd., mining-equipment manufacturers, will visit the Heaton Works of C. A. Parsons & Co., Ltd., accompanied by members of the Productivity Committee. They will be shown round the works and later there will be discussions between the visitors and their hosts on various matters, including methods of payment, costing and estimating, welfare work, apprentices, works committees, and absenteeism. On October 1 a party from Thomas Hedley & Co., Ltd., soap-powder manufacturers, Newcastle-upon-Tyne, will make a similar visit to the works of Victor Products, Wallsend.

DEPRECIATION ALLOWANCE ON SHIPS.—On the occasion of the launch of the Jersey Mist the ninth ship built by William Doxford & Sons, Ltd., Sunderland, for Morel Ltd., London, Mr. J. Ramsay Gebbie, managing director of Doxford & Sons, stated that shipowners were allowed a depreciation allowance by the Government, based on the cost of their ships. The cost of building new ships had, however, increased to such an extent that this allowance was now inadequate. Unless the Government did something about this matter, the country's tramp fleet would decline still further. A new ship which cost 100,000*l*. in 1937, would now cost 500,000*l*.

DOCK GATES FOR REGENT'S CANAL DOCK.—Messrs. Head, Wrightson & Co. Ltd., Thornaby-on-Tees, have dispatched to London two 56-ton dock gates for the Regent's Canal Dock, ordered by the Docks and Inland Waterways Executive. The gates were towed to London by two tugs.

COMPLETION OF EXTENSIONS TO DRY DOCKS AT SOUTH SHIELDS.—The Middle Docks and Engineering Co., Ltd., South Shields, have completed extensions to their three dry docks. The work, which began two years ago, has been carried out without interrupting normal ship-repair work. The docks have been lengthened, respectively, by 25, 71 and 40 ft. The contractors were Brims & Co., Ltd., Newcastle-on-Tyne.

THE LATE MR. J. T. ROBSON.—The death has occurred of Mr. John T. Robson, former joint secretary of the Northumberland and Durham Coalowners' Associations. He was 80 years of age and served the organisations for 55 years. He had also been secretary of the Colliery Managers' Association for some years.

LANCASHIRE AND SOUTH YORKSHIRE.

SHORT COURSE ON IRON AND STEEL MAKING FOR PUBLIC-SCHOOL BOYS.—At the invitation of the United Steel Companies, Limited, Sheffield, 35 senior boys from 16 public schools are to spend the first week of September in Sheffield as the guests of the firm in order to take part in a short course on iron and steel making. The firm hopes that this course will benefit the young men who attend and will assist them in deciding the kind of career they would like to follow when the time comes for them to make their choice. The boys will be in residence at University Hall, Endcliffe Vale-road, Sheffield, under the supervision of Mr. T. Fletcher, T.D., A.M.I.Mech.E., the company training supervisor, who will live with them during the course. The boys will be entertained to dinner each evening at University Hall where they will meet representatives of the board, the management and the head-office staff, and be given an opportunity of discussing points of detail with them.

NEW BRIDGE ACROSS THE RIVER MERSEY.—The construction of a new suspension bridge across the River Mersey, from Runcorn to Widnes, will be commenced during the coming autumn. Tenders for piers and anchors for a two-cable bridge will be invited immediately. The original design was for the erection of a bridge with a single carriageway, so constructed that it could be converted to a dual carriageway. This scheme was objected to by the Ministry of Transport on the ground of its cost. The plans now approved, which will provide for a permanent single carriageway and one footpath, will affect a saving of 114,000*l*., and allow for more rapid construction. The new structure will replace the existing transporter bridge, at an estimated cost of 1,300,000*l*., and will take three years to complete.

ELECTRICITY SUPPLY.—It is officially stated that the electricity supply in the East and West Ridings has now reached a stage when it is possible to dispense with the need for organised schemes of load spreading during the coming winter, provided there is continued use, when necessary, of private generating plant, and the exercise of the utmost economy in electric power during peak hours on weekdays.

REDUNDANT EMPLOYEES.—A recession in the demand, accentuated by high American import duties, has made it necessary to dispense with the services of 30 semi-skilled employees at the factory of Joseph Thompson, Ltd., manufacturers of small circular saws, Chesterfield. It is hoped to re-engage some of the men gradually as trade improves.

CLOSURE OF THE NUNNERY COLLIERY.—Nunnery Colliery, Sheffield, was closed for coal-getting on August 28. It had been in operation for 93 years, and some of the seams worked latterly were so near the surface that there was risk of subsidence in Sheffield's industrial area. Some of the miners have been transferred to the nearby Treeton colliery, where a double-shift system has been introduced to provide employment for some of the displaced men. In this way it is anticipated that the output at Treeton will be increased by about 1,000 tons a week. Of 75 men, for whom no alternative work can be found by the National Coal Board at present, 25 men under 40 years of age have refused underground work.

TRAINING IN MANAGEMENT.—Industry in Sheffield has organised several training schemes to fit men for executive positions, and further facilities are contemplated in the Sheffield region. Investigations have been started by a working party set up by the Yorkshire Council for Further Education to see how best the needs of local industry can be met. The working party, under the chairmanship of Mr. J. C. W. Stead, includes representatives of both education and industry, and has been asked to submit a report by the end of the year.

THE MIDLANDS.

PITHEAD BATHS AT WALSALL WOOD COLLIERY.—Mr. J. Jones, labour director, for the West Midlands Division of the National Coal Board, opened new pithead baths at Walsall Wood Colliery, Brownhills, Staffordshire, on August 22. The new baths, which cost 35,000*l*., have accommodation for 816 men. The building also includes an ambulance room. Walsall Wood Colliery, one of the outlying pits of the Cannock Chase coalfield, produces household and manufacturing coal from eight seams, and employs between 600 and 700 men underground.

THE STANDARD MOTOR COMPANY'S KIRKBY FACTORY PROJECT.—The 50-acre site at Kirkby Trading Estate, Liverpool, which was being prepared for a new factory for the Standard Motor Co., Ltd., Coventry, has been placed in the hands of agents for sale. The site, which has been levelled and has had a certain amount of pile-driving done on it, was to have been used for a new factory for making aircraft engines and spare parts. The project was suspended as a result of cuts in the defence programme, and has now been abandoned.

AUSTIN VEHICLE EXPORTS.—The Austin Motor Co., Ltd., Longbridge, Birmingham, have exported over 500,000 vehicles since 1946, their share of the total exports by the leading British motor-vehicle manufacturers being nearly 23 per cent. They claim to have earned more foreign currency than any other firm in the industry, and put their dollar earnings alone at 118,500,000

NEW BRANCH TECHNICAL COLLEGES.—Two new branch technical colleges are to be opened in Birmingham this month, in time for the 1953-54 winter session. They are at Garret's Green, Yardley, and Brooklyn Farm, Aldridge-road. The new colleges form part of a group of 21 which Birmingham has planned under its long-term programme for adult education, and will relieve the pressure on the older Aston, Handsworth and Central Technical Colleges. Each of the new colleges is fully equipped to provide full-time and part-time courses in various branches of mechanical and electrical engineering, as well as in a number of other subjects.

IMPROVED HOIST FOR COAL CONVEYING.—A new type of hoist for bringing coal to the pit surface by means of hydraulic ramps and electrically-controlled conveyor belts has been installed by the National Coal Board at Rawdon Colliery, North Leicestershire, in the East Midlands Division; it came into operation in the middle of last month. Mr. J. J. Torrance O.B.E., general manager of the Division's No. 7 area has been responsible for the design of the new system, which is still largely in the experimental stage. It was stated by an official of the Board at the close of the first week's working that similar equipment was likely to be introduced at other collieries, after certain improvements and adjustments had been made. Previously, tubs of coal at the Rawdon Colliery had to be placed in the cages, wound to the surface, and unloaded by hand.

SOUTH-WEST ENGLAND AND SOUTH WALES.

UNEMPLOYMENT STATISTICS IN WALES.—In spite of the difficulties encountered in the tin-plate and aluminium industries in Wales during the past year, unemployment figures have maintained their downward trend. This was described by a Ministry of Labour spokesman at a meeting of the Welsh Board for Industry last week as "a remarkable achievement." Of the many tin-plate employees made redundant by the closing of the old-type works, only about 300 remain registered as unemployed. Unemployment figures for Wales at mid-July showed 23,330 totally idle, against 28,718 in May. The mid-July figure was the lowest since September, 1951.

PROJECTS FOR NEW INDUSTRIES IN WALES.—The Welsh Board for Industry have received a report from the Board of Trade stating that there has been a steady flow of inquiries from firms in Wales seeking additional, and in some cases, alternative, space. These have included manufacturers of rubber, plastic, and textile-insulated cables, packing cases, tubular furniture and metal alloys.

EXTRA PAY FOR DIRTY DIVING WORK.—Tank divers engaged in the repair of oil tankers at the Channel Dry Dock, Cardiff, staged a lightning strike during last week. They claimed 10s. extra pay for dirty work. The men returned to work on the following day, and, after negotiations, accepted the pay offer of the employers.

NOTICES OF MEETINGS.

It is requested that particulars for insertion in this column shall reach the Editor not later than Monday morning in the week preceding the date of the meeting.

INSTITUTION OF PRODUCTION ENGINEERS.—*Birmingham Graduate Section:* Tuesday, September 8, 7 p.m., James Watt Memorial Institute, Birmingham. Films on "Mechanical Handling." *Coventry Graduate Section:* Tuesday, September 15, 7.30 p.m., The Hare and Squirrel Hotel, Coventry. Discussion on "Aspects of Production Engineering." *Birmingham Section:* Wednesday, September 16, 7 p.m., James Watt Memorial Institute, Birmingham. "The Ethics of Production," by Mr. R. W. Mann. *Derby Section:* Monday, September 21, 7 p.m., Midland Hotel, Derby. Presidential Address, by Mr. W. C. Puckey.

INCORPORATED PLANT ENGINEERS. — *Manchester Branch:* Tuesday, September 8, 7.15 p.m., Engineers' Club, Manchester. Films on "Atomic Warfare and Civil Defence." *North-East Branch:* Thursday, September 10, 7 p.m., Roadway House, Oxford-street, Newcastle-upon-Tyne. "Maintenance Costs," by Mr. H. Whitfield. *Glasgow Branch:* Wednesday, September 16, 7 p.m., Scottish Building Centre, 425-427, Sauchiehall-street, Glasgow, C.2. "Education and the Plant Engineer," by Mr. H. N. Henry. *Merseyside and North Wales Branch:* Monday, September 21, 7.15 p.m., Radiant House, Bold-street, Liverpool. "Paint in Industry," by Mr. P. I. Gay.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*Midlands Centre:* Tuesday, September 8, 7.30 p.m., Crown Inn, Broad-street, Birmingham. Open Meeting. *North-West Centre:* Wednesday, September 16, 7.30 p.m., The Victoria Hotel, Wigan. "The Use and Abuse of Fuels," by Mr. W. E. P. Johnson. *Yorkshire Centre:* Thursday, September 17, 7.30 p.m., Hotel Metropole, King-street, Leeds, 1. "Vehicle Maintenance from the Aspect of Safety," by Mr. A. H. Dack.

INSTITUTE OF PETROLEUM.—Wednesday, September 9, 5.30 p.m., Manson House, 26, Portland-place, W.1. "Autofining," by Mr. F. W. B. Porter.

INSTITUTION OF MECHANICAL ENGINEERS.—*Southern Branch:* Wednesday, September 9, 7.30 p.m., Royal Aircraft Establishment Technical College, Farnborough. A paper of aeronautical interest will be read. *North-Western Branch:* Thursday, September 24, 6.45 p.m., Engineers' Club, Albert-square, Manchester. "Design of Precision-Grinding Machines," by Mr. C. H. Asbridge. *Western and Southern Branches:* Friday, September 25, 6.30 p.m., South Dorset Technical College, Weymouth. Joint Meeting. "The Electricity Supply Industry," by Mr. E. A. Logan.

ROYAL AERONAUTICAL SOCIETY.—Monday, September 14, 6 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, Westminster, S.W.1. Forty-First Wilbur Wright Memorial Lecture on "Structures," by Professor N. J. Hoff.

INSTITUTE OF PACKAGING.—*Northern Area:* Monday, September 14, 6.30 p.m., The Old Nag's Head Hotel, Manchester. Debate on "Sales Managers Do Not Appreciate the Importance of Packaging." *Midland Area:* Monday, September 21, 6.30 p.m., The Imperial Hotel, Birmingham. "Food Preparation and Related Packing Problems, Solved and Unsolved," by Dr. H. R. Barnell.

COMBUSTION ENGINEERING ASSOCIATION.—*Northern Section:* Wednesday, September 16, 2.15 p.m., The Queen's Hotel, Leeds. Informal Discussion on "The Advantages and Disadvantages of a Delivered Price Scheme for Industrial Coals," introduced by Mr. R. J. Moffat.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—Wednesday, September 23, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, Westminster, S.W.1. Presidential Address, by Mr. R. C. Bond.

ROYAL SANITARY INSTITUTE.—*Grimsby Sessional Meeting:* Thursday, September 24, 11.30 a.m., Town Hall, Grimsby. Joint meeting with the *East Midland District* of the INSTITUTION OF MUNICIPAL ENGINEERS. (i) "Grimsby Main Drainage: Combined Sewage and Surface-Water Pumping Stations," by Mr. S. W. Norman; and (ii) "A Modern Abattoir: Before and After," by Mr. Harold Parkinson.

TELEVISION SOCIETY. — Thursday, September 24, 7 p.m., Cinematograph Exhibitors' Association, 164, Shaftesbury-avenue, W.C.2. "Transistors and Other Crystal Valves," by Mr. D. D. Jones.

FORMATION OF CINEMATOGRAPH GROUP.—To enable executives and others to keep themselves informed of developments in the use of films as an aid to production and sales, the Institute of British Photographers, 49, Gordon-square, London, W.C.1, have formed a Cinematograph Group within the Institute.

CONTRACTS.

The Fraser and Chalmers Engineering Works of the GENERAL ELECTRIC CO. LTD., Magnet House, Kingsway, London, W.C.2, are now engaged upon three orders, two of them from the National Coal Board. The first is for coal-handling plant, including a wagon tippler, for the Aberaman Phurnacite plant. The contract calls for a "Marshall" 35-ton special side-discharging type wagon tippler, which will handle wagons of from 8 to 24½ tons capacity, tipping a total of 12 wagons an hour. The contract will also include a belt-conveyor system and scraper conveyors for transporting coal from the wagon tippler and delivering it to storage bunkers. The second contract is for two electric winding equipments for the new sinkings at Lea Hall Colliery, Cannock Chase Area, West Midlands Division. The equipment includes a single-drum winder designed for an output of 280 tons an hour, winding from a depth of 1,412 ft. and giving a net load per wind, of 6 tons of coal. In addition, a double-drum winder is to be provided. This has been designed for an output of 250 tons an hour and will wind from depths of 1,032 ft., 1,420 ft., and 1,732 ft. The third order is for a 5,000-kW turbo-alternator set, complete with condensing plant, for an extension to the existing power station at the East Moors Works, Cardiff, of Guest Keen Baldwins Iron and Steel Co. Ltd.

YARROW & CO., LTD., Scotstoun, Glasgow, W.4, have received an order from the Government of the Sudan for the building of three twin-engined motor tugs, each having a displacement of 256 tons. The propelling machinery consists of 540 b.h.p. engines, supplied by RUSTON AND HORNSBY, LTD., Lincoln.

LEYLAND MOTORS, LTD., Leyland, Lancashire, have obtained an order from Copenhagen for 28 Royal Tiger omnibus chassis, furnished with underfloor Diesel engines. The bodies will be built in Denmark. Ten of the vehicles will have special rear platforms for standing passengers and will have a total capacity of 75 passengers, with seats for 28. The other 18 omnibuses will carry 70 passengers, 33 of them seated.

LAUNCHES AND TRIAL TRIPS.

M.S. "TUNGUFOSS."—Single-screw cargo vessel, with accommodation for a small number of passengers, built and engined by Burmeister and Wain Ltd., Copenhagen, Denmark, for H/f. Eimskipafjelag Islands, Reykjavik, Iceland. Main dimensions: 240 ft. between perpendiculars by 38 ft. by 22 ft. 6 in. to main deck; deadweight capacity, 1,700 tons on a summer draught of 15 ft. 1½ in.; cargo capacity, 105,000 cub. ft. Seven-cylinder single-acting two-stroke Diesel engine, developing 1,400 b.h.p. at 300 r.p.m. Launch, August 12.

M.S. "JANEGA."—Single-screw oil tanker, built and engined by the Götaverken Shipyard, Gothenburg, Sweden, for the Spermacet Whaling and Shipping Co., Panama City, Panama. Main dimensions: 550 ft. overall by 66 ft. by 39 ft. 3 in.; deadweight capacity, 17,570 tons on a draught of 30 ft. 2¼ in. Götaverken nine-cylinder single-acting two-stroke Diesel engine, developing 6,750 b.h.p. at 112 r.p.m. Loaded speed, 14¾ knots. Delivered, August 18.

M.S. "BERA."—Single-screw oil tanker, built and engined by the Götaverken Shipyard, Gothenburg, for the Rederi A/B. Transocean, Gothenburg, Sweden. Main dimensions: 508 ft. by 63 ft. 6 in. by 35 ft. 2 in.; deadweight capacity, 13,500 tons on a draught of 27 ft. 6 in. Götaverken seven-cylinder single-acting two-stroke Diesel engine, developing 5,250 b.h.p. at 112 r.p.m. Loaded speed, 14½ knots. Launch, August 19.

M.S. "JERSEY MIST."—Single-screw cargo vessel, built and engined by William Doxford and Sons, Ltd., Sunderland, for Morel, Ltd., London, E.C.3. Main dimensions: 420 ft. between perpendiculars by 57 ft. 9 in. by 28 ft. 6 in.; deadweight capacity, about 9,100 tons on a draught of about 25 ft. 10 in. Four-cylinder opposed-piston oil engine, developing approximately 3,300 b.h.p. and a service speed of 13 knots. Launch, August 25.

M.S. "JARENA."—Single-screw oil tanker, built and engined by Harland and Wolff, Ltd., Belfast, for Anders Jahre & Co., Sandefjord, Norway. One of a series of five similar vessels for these owners. Main dimensions: 540 ft. between perpendiculars by 73 ft. by 39 ft. 3 in. to upper deck; deadweight capacity, about 18,500 tons. Harland-B. and W. six-cylinder two-stroke single-acting opposed-piston oil engine. Launch, August 25.

S.S. "NORTH QUEEN."—Single-screw cargo vessel, built by Short Brothers, Ltd., Sunderland, for Mr. A. G. Pappadakis, London, E.C.3. Third vessel built for this owner. Main dimensions: 438 ft. between perpendiculars by 59 ft. 6 in. by 37 ft. 7 in. to shelter deck; deadweight capacity, 9,850 tons on a draught of 25 ft. 9½ in. Triple-expansion steam engine of reheat design and three multitubular oil-burning boilers, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Sunderland. Speed, 12 knots in service. Launch, August 25.

PERSONAL.

BY arrangement with the Iron and Steel Holding and Realisation Agency, the board of the Scunthorpe Rod Mill Ltd. has been reconstituted as follows: SIR CHARLES BRUCE GARDNER, Bt., is chairman, and the other directors are MR. N. R. R. BROOKE, MR. W. L. JAMES and MR. K. S. PEACOCK.

MR. HAROLD DREW, A.C.G.I., B.Sc. (Eng.) (Lond.) M.I.Mech.E., chief engineer, Vauxhall Motors Ltd., Luton, Bedfordshire, has been appointed assistant chief engineer of General Motors overseas operations with headquarters in Detroit, U.S.A. MR. MAURICE PLATT, M.Eng.(Sheffield), M.I.Mech.E., formerly executive engineer to Vauxhall Motors Ltd., succeeds Mr. Drew as chief engineer. Mr. Platt is the chairman of the Automobile Division of the Institution of Mechanical Engineers.

MAJOR-GENERAL W. A. LORD, C.B.E., M.Eng. (L'pool), M.I.Mech.E., Director of Mechanical Engineering, Middle East Land Forces, is to be Director of Mechanical Engineering, War Office, with effect from January, 1954. BRIGADIER G. R. TAYLOR, C.B.E., M.I.Mech.E., deputy Director of Mechanical Engineering, Anti-Aircraft Command, is to be Director of Mechanical Engineering, Far-East Land Forces, as from November, 1953, and COLONEL L. H. GORDON, M.I.Mech.E., officer commanding 14 Command Workshop, is succeeding Brigadier Taylor as deputy Director of Mechanical Engineering, Anti-Aircraft Command, as from October, 1953.

MR. J. SAVAGE, B.Sc., F.Inst.P., has been appointed head of the Physics Department of the British Iron and Steel Research Association, 11, Park-lane, London, W.1, with effect from October 1, 1953. He will take the place of MR. M. W. THRING, M.A. (Cantab.), F.Inst.F., F.Inst.P. who is succeeding PROFESSOR R. J. SARJANT, O.B.E., D.Sc., A.R.C.Sc., D.I.C., in the Chair of Fuel Technology in the University of Sheffield.

MR. GILBERT SALTER, of Stourbridge, has been appointed by the Minister of Fuel and Power to be a member of the West Midlands Gas Consultative Council.

MR. J. W. STEVENS, who has served on the board of directors of the Express Lift Co., Ltd., of Northampton and has occupied a managerial position with the company since its formation, retired on July 31.

MR. C. BIRCH, district operating superintendent, British Railways, Wakefield, Yorkshire, has been appointed to a similar post at Sunderland, where he succeeds MR. E. E. COWELL, who has been transferred to Newcastle-upon-Tyne.

GROUP-CAPTAIN E. C. LEWIS, R.A.F. (ret.), of Berwick-court, Berwick, Sussex, has been appointed to the board of Hick, Hargreaves & Co., Ltd., Soho Ironworks, Bolton.

MR. H. A. JARVIS, of Broadwindsor, Dorset, has been appointed engineer, surveyor and water engineer to Stafford Rural District Council, in succession to MR. G. S. DANIELL, who is leaving to take up an appointment with Wokingham Rural Council. Mr. Jarvis takes up his new position on September 21.

MR. J. W. BOTCHERBY has retired from the position of National Coal Board colliery wagon-shops manager, at Seaham. He has been at the shops for 35 years and became manager six years ago.

MR. FENTON HALL has been appointed general sales manager of materials handling equipment for the British Division of the Yale and Towne Manufacturing Co., Willenhall, Staffordshire. With the completion of a large addition to its Wednesfield, Staffordshire, plant, the British Division is expanding its production of materials-handling equipment, including power-driven industrial trucks and hand-lift trucks and hoists.

MR. G. H. TOOP, A.M.I.Mech.E., has left his position as field development engineer with George Kent Ltd., Luton, Bedfordshire, to join George Kent (S.A.) (Pty.) Ltd., Johannesburg, as development engineer specialising in automatic process control.

Following the announcement of the formation of the Stud Welding Organisation of Crompton Parkinson Ltd., Crompton House, Aldwych, London, W.C.2, for the unified sales and servicing of both Nelson and Cyc-Arc stud-welding equipment, it is now further announced that MR. F. FOSTER, M.Sc., A.M.I.E.E., is the general manager, with MR. R. W. TAYLOR, A.M.I.E.E., M.Inst.W., as sales manager (home).

COCHRAN & CO., ANNAN, LTD., Annan, Dumfriesshire, state that their office in Glasgow is now at 139, Bath-street, C.2. (Telephone: Central 4929.)

THE FAIRMILE CONSTRUCTION CO. LTD., Cobham, Surrey, are extending their activities. They have taken a major holding in a yard at Hayling Island, Hampshire, and acquired the Berwick Shipyard at Berwick-on-Tweed, Northumberland.

A.E.L. MASH AND ASSOCIATES have acquired larger premises at Avenue House, 25, Shaftesbury-avenue, London, W.1. (Telephone: GERrard 3362.)

AUTOMATIC RADAR METEOROLOGICAL STATION.

(*For Description, see Page 299.*)

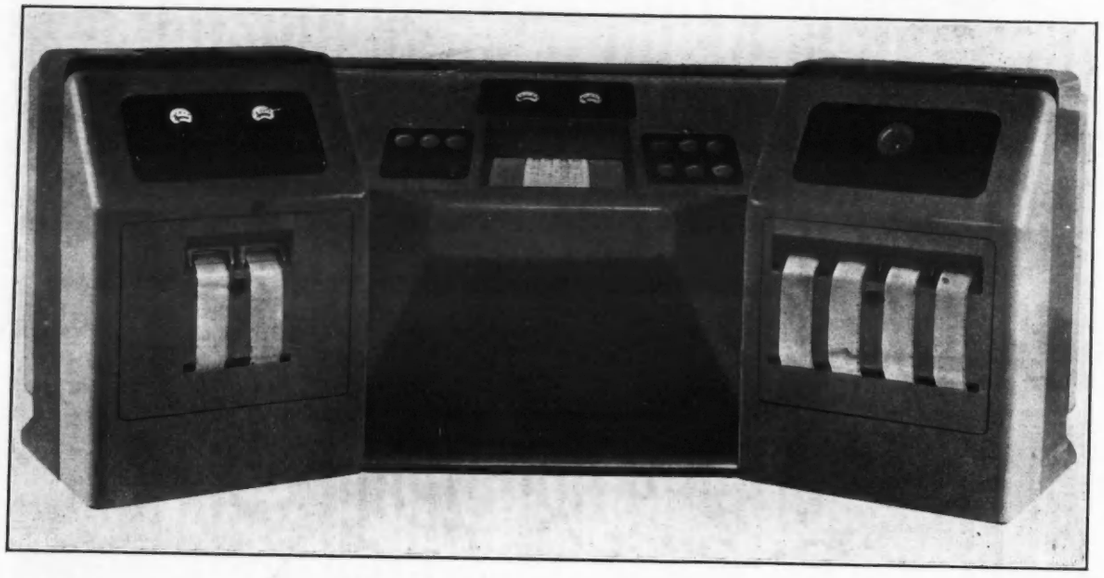


FIG. 3. RECORDING AND TELEMETERING UNIT.

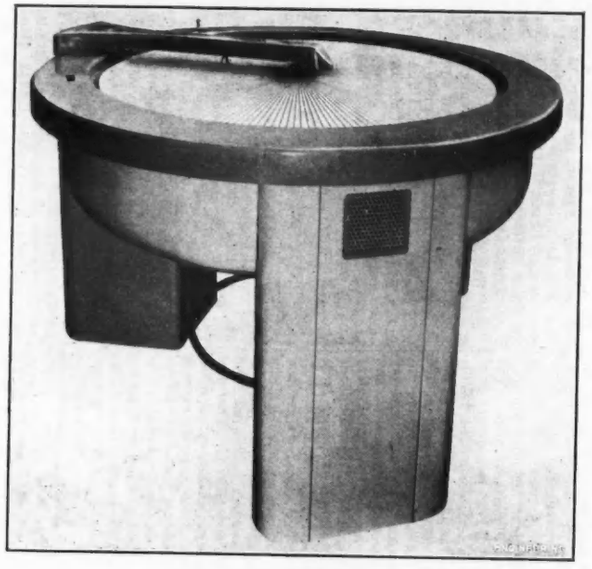


FIG. 4. WIND COMPUTER.

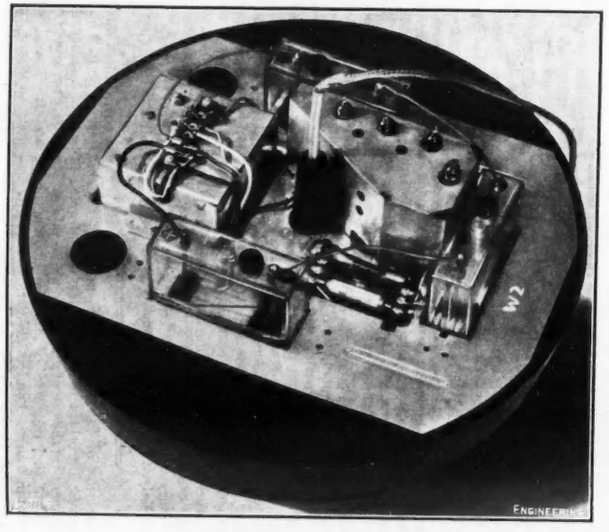


FIG. 5. WIND AIRBORNE UNIT.

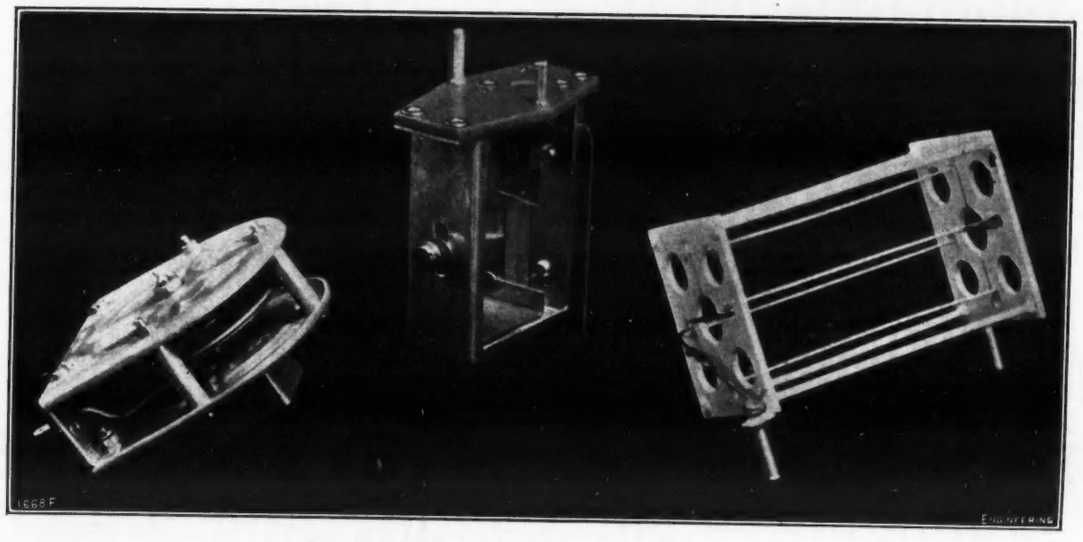


FIG. 6. METEOROLOGICAL ELEMENTS OF SONDE UNIT.

ENGINEERING

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

Registered at the General Post Office as a Newspaper.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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For Canada	£5 5 0

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ADVERTISEMENT RATES.

Terms for displayed advertisements can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 10*s.* for the first four lines or under, and 2*s.* 6*d.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 30*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Monday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received 16 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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ENGINEERING

FRIDAY, SEPTEMBER 4, 1953.

VOL. 176. No. 4571.

STEAM AND DIESEL ON TRIAL.

THE series of locomotive test bulletins which British Railways are publishing now includes, for the first time, one on a non-steam locomotive.* It relates to a 1,750-h.p. main-line Diesel-electric locomotive of the Southern Region's Co-Co type, and the results have been presented in a manner which facilitates a comparison between this and other forms of motive power. Though it is interesting to set this bulletin beside a previous one on the standard Class-7 4-6-2 mixed-traffic steam locomotive, useful comparisons between the two sets of results are not readily made. It is easy, of course, to compare overall thermal efficiencies, but such a comparison is not new nor is it particularly germane to the overall financial efficiency of railway operation. An estimate of fuel costs, assuming typical train loads and speeds, leads to the tentative conclusion that there is not much to choose, in this respect, between steam and Diesel. But an accurate comparison of fuel costs, if it is to be realistic, requires a knowledge of the trains worked, figures of average train loads, maximum and minimum train loads, the profiles of the lines over which the trains are worked, the running time-table, and all the other factors which together determine the operating conditions.

A comparison of this kind is clearly intended by British Railways. In the steam-locomotive bulletin it is stated that the first part of the test results defines the relationship between coal "as fired," water as drawn from the tender, and tractive effort and horse-power (both at the drawbar). These data, is it pointed out, are applicable to the commercial purpose of examining loadings and schedules in order to obtain a reduction in fuel consumption by working the locomotives as nearly as possible at the point of maximum operating efficiency. Similarly, part of the Diesel-locomotive bulletin deals with the fuel consumption "related to drawbar tractive effort and horse-power for the immediate commercial purpose of relating loadings and schedules to obtain maximum operating efficiency." Only when both forms of motive power are being used at the optimum efficiency, and records of their performance and costs have been compiled over a reasonably long period, will it be practicable to make a worth-while assessment of their relative merits.

The temptation to make a comparison on the basis of the test bulletins soon fades when the details concerning the mileages run by the locomotives are examined. Two Class-7 steam locomotives were used for the tests and both were practically new at the beginning: No. 70005 had run only 560 miles in traffic and No. 70025 only 1,040 miles. For the purposes of the tests, No. 70005 ran 6,890 miles on the Rugby locomotive-testing plant and about 5,000 miles on the road. The other engine (No. 70025) ran 6,350 miles on the Rugby plant only. The Diesel-electric locomotive, No. 10202, however, had completed 89,270 miles when a series of service tests was commenced in April, 1952, and the Diesel engine had run for 2,680 hours. These service tests were carried out on normal revenue-earning trains in order to obtain average performance and efficiency values in representative service and to examine the relationship between the designed power steps and the conditions in which they were actually used.

In the design of the Diesel-electric locomotive, as worked out by the former Southern Railway, high-speed performance was sought, but it was found that the train schedules required improved acceleration characteristics. At the conclusion of the service tests, therefore, the gear ratio was altered from 52 : 21 to 65 : 17, and two stages of field-weakening were provided where before there was only one. By this time the locomotive had completed 100,880 miles and the Diesel engine 3,025 hours. An intermediate overhaul carried out at the same time as the alteration of the gear ratio consisted only of tyre-turning and an inspection of the Diesel engine, in which four of the 16 pistons were withdrawn, but no parts were replaced and no decarbonisation was carried out. The analytical tests were commenced in October, 1952, when the mileage was 130,310 and the engine hours were 3,890. Up to this time the Diesel engine had not had an overhaul, the only work being the weekly inspection and maintenance, and in this connection the only components requiring regular attention were filters and fuel injectors; the latter were originally changed every four weeks, but subsequently every eight weeks. Between the special trains in the analytical series of tests the locomotive worked a service train from Exeter to Waterloo and back. Normally, it is employed, with a similar locomotive, No. 10201, on express passenger trains between Waterloo and Exeter or Weymouth, making two round trips on one or the other route each day for six days a week.

The higher availability and utilisation of the Diesel-electric locomotive, compared with a steam engine, are factors of great significance in railway operation, and are taken into account, together with fuel costs, first cost and other factors, in assessing the merits of this form of motive power. The service tests were carried out on the 1 p.m. train from Waterloo to Exeter Central, stopping at six stations *en route*, and on the 7.30 a.m. train in the

* *Performance and Efficiency Tests: Southern Region 1 Co-Co 1 1750-h.p. Main Line Diesel Electric Locomotive; Bulletin No. 9; and Performance and Efficiency Tests with Exhaust Steam Injector: British Railways Standard Class 7 2-Cyl. 4-6-2 Mixed Traffic Locomotive; Bulletin No. 5.* Publicity Officer, Railway Executive, Room 323, 222, Marylebone-road, London, N.W.1. [Price 10*s.* each, post free].

reverse direction, stopping at eight stations. The load varied from eight vehicles (265 tons) to 13 vehicles (432 tons), and tests were undertaken on two runs in each direction. The run of 171 miles was done at an average speed (running time) of 49·4 m.p.h. on the slowest run and 54·0 m.p.h. on the fastest. The average drawbar horse-power ranged between 663 and 761, and the locomotive efficiency was between 17·6 and 19·6 per cent. when expressed as the ratio of the heat equivalent of the work done at the drawbar to the total oil used multiplied by the gross calorific value, or between 18·1 and 20·2 per cent. when only the oil used under power was reckoned.

The train schedules required the locomotive to be run in the highest notch (No. 8) for most of the time that it was working under power, i.e., when a measurable force was being exerted at the drawbar. On one test, for example, it was worked in notch 8 for 75 per cent. of the time under power. During the remainder of the running time either the working was eased or the locomotive was drifting or braking. It is by adjusting the working during these periods that day-to-day checks and restrictions are countered. Thus an increase in the loads, a tightening of the time-table, or an increase in the normal level of delays and checks would reduce the margin and the punctuality of working would be affected. The test results showed that operation in the highest notch was fully justified, since the fuel consumption, in lb. per drawbar-horse-power per hour, was lowest under these conditions. The bulletin concludes with the general observation that efficiency is maintained over a wide range of train load and running speeds, thus confirming the suitability of the locomotive for mixed-traffic working. There is a considerable choice of notches covering the lower powers and speeds—an advantage in handling heavy loose-coupled freight trains—but there is a part of the characteristic curve in the higher power and speed area which is not well divided by intermediate notches. The bulletin suggests that this is a point which should be considered in the design of future locomotives, though no disadvantage was noticed in practice on passenger and partly-braked freight trains up to 600 tons.

The steam locomotive was tested, both on the Rugby stationary plant and on the road, at exceptionally high steaming rates—so high, in fact, that two firemen were employed. These rates, the bulletin observes, were "greater than anything normally required for train working in Great Britain, even for periods of quite limited duration." The maximum steam supply to the cylinders to be sustained continuously on the test plant for well over an hour was 31,610 lb. per hour, but on one of the road tests a rate of 37,560 lb. per hour was maintained for 45 minutes, using the railways' mobile testing units to provide additional train resistance. This rate corresponds to the haulage of an 850-ton passenger train over the Carlisle-Leeds route at the times appropriate to a "limited-load" train. The rostered load for a Class-7 engine over this route is only 405 tons; thus, the difference is an indication of the reserve of power which the engine possesses to meet adverse operating conditions. At that very high rate of working, however, the limit of adhesion was being reached. When rail conditions are good this limit usually exceeds the corresponding limit on the test plant (presumably due to the curved tread of the test-plant rollers as compared with the straight head of the track).

The advantages of a large boiler were demonstrated. It serves as a reservoir of heat and steam, so that the engine readily deals with short periods of heavy demand, such as acceleration up a gradient after a check, and temporary adverse firing conditions. Moreover, a large grate is able to carry more clinker or ash from poor-quality coal before the air supply through the fuel bed becomes sufficiently restricted to have an adverse effect on steaming. The boiler efficiency, using South Kirby coal, was still 75 per cent. when 3,000 lb. of coal per hour was fired, which is about the upper limit for hand firing. A modified "Farnboro'" indicator was used on the cylinders. It gives diagrams on an angle-of-rotation basis, examples of which are reproduced in the bulletin. Comparative tests made with the latest Dobbie McInnes piston indicator showed that, with the latter fitted as close as possible to the cylinder, the two sets of diagrams were within 1 per cent. of each other. The lowest specific steam consumption was 13·28 lb. per indicated horse-power per hour at 20 per cent. cut-off at 70 m.p.h., when 20,000 lb. of steam per hour were being used to develop 1,506 indicated horse-power. At this point the cylinder thermal efficiency was 14 per cent., which is 68 per cent. of the maximum efficiency possible with the Rankine cycle. The bulletin gives a large number of graphs and other results, but the task of applying them to the operating needs of the railway is probably more difficult than the similar problem with the Diesel-electric locomotive.

UNIVERSITY FINANCE.

FOR many centuries, the maintenance of universities and their work has depended essentially, in this country, on private benefactions; but it is a matter of common knowledge that this source can be relied upon no longer to augment the original grants and bequests on which the fabric of university education was founded. Hence arose the appointment, by the Lords of the Treasury, of the University Grants Committee, whose present responsibility is "To inquire into the financial needs of university education in Great Britain; to advise the Government as to the application of any grants made by Parliament towards meeting them; to collect, examine and make available information on matters relating to university education at home and abroad; and to assist, in consultation with the universities and other bodies concerned, the preparation and execution of such plans for the development of the universities as may from time to time be required in order to ensure that they are fully adequate to national needs." How this charge is interpreted in practice is well demonstrated in a recent report,* entitled *University Development*, covering the operations of the Committee during the five years 1947 to 1952.

At the beginning of the five-years' period, the Committee were concerned with 16 universities, five university colleges, and two colleges of technology; but since then two of the university colleges (those of Nottingham and Southampton) have obtained charters as universities, and a new university college has been founded in North Staffordshire, making the number of universities 18 and of university colleges four. The two colleges of technology are those in Manchester and Glasgow, where much of the work is concerned with preparation for the degrees awarded by the respective universities of those cities. It is a commentary on the difficulties of the times that the grants authorised by Parliament in response to the recommendations of the Committee have risen in a mere ten years from some 2*l.* millions per annum to more than 25*l.* millions. Even so, the moneys voted are not sufficient to provide for all of the expansion that is deemed to be necessary, so that, for example, the Rector of King's College, Newcastle-upon-Tyne, which is a part of the University of Durham, has been obliged to make a public appeal for 250,000*l.* to meet the needs "of the greatest urgency . . . for which we cannot expect help from the National Exchequer."

It is not to be assumed, from the formulation of this appeal, that the University Grants Committee have ignored any legitimate claims on their attention, or that, in the vernacular, they have in any way "fallen down on the job" entrusted to them. In addition to the recurrent grants made to augment the regular income of the universities, which represented 64·5 per cent. of that total income in 1951-52, as against only 31·4 per cent. in 1938-39, they have disbursed many millions of pounds in non-recurrent grants towards the cost of erecting and equipping new buildings, and otherwise extending the accommodation necessary to meet the increase of 66 per cent. in the full-time student population since before the war—from 50,246 in 1938-39 to 83,458 in 1951-52. It is of interest that the increase in the number of students of science and technology, which has doubled since 1938-39, has been achieved much more rapidly than was envisaged in the Barlow Report of 1946, which recommended that the output of graduates in these subjects should be doubled, but expected the process to take about ten years.

In the case of King's College, Newcastle, there were about 1,300 students in 1939; now there are 3,100, distributed among the faculties of Arts, Medicine, Science and Technology. Some expansion is contemplated in the accommodation for Arts and Medicine, but not a great deal, and much of that will be merely the completion of plans which were well on the way towards fulfilment before the war. The main purpose of the appeal by the Rector, Dr. C. I. C. Bosanquet, is "to create and maintain in the Newcastle Division of the University of Durham what will be, in effect, a North Eastern University Institute of Science and Technology, with a student body of between 1,500 and 2,000"—to quote from the last report submitted to the Council by Lord Eustace Percy, who was Rector from 1937 to 1952. This, in Lord Percy's opinion, represents "the minimum contribution which this region ought to make towards the national policy of scientific and technological development"; but, he added, "I do not see how it is to be carried out unless the industries of the North East are prepared to contribute towards its cost." In 1938-39, King's College obtained not quite 46 per cent. of its income from Parliamentary grants. In 1946-47, the proportion was not far short of 61 per cent., and in 1952-53 it will be nearly 75 per cent. "Here," said Lord Percy, "we have reached a danger point . . . The Parliamentary scale must always tend to be conformity to a standard; the University scale must be excellence. It is for the financing of that crucial difference between excellence and a mere decent standard that universities must look, not to Governments, but to private benefaction." As we have indicated, personal benefaction is no longer a practicable source. Only industry, with its greater resources (and, indeed, its vastly greater expectation of benefiting from university research and learning), can supply the deficiency adequately.

The purposes for which the appeal is being made are partly the provision of capital sums and partly to augment the annual income. It is suggested that, of the 250,000*l.* aimed at, 100,000*l.* should be applied to capital, half of that sum as working capital for general college purposes and the other half on obtaining scientific and other equipment. The 150,000*l.* to be devoted to the augmentation of income would be made up of 50,000*l.*, to be expended over ten years, to endow post-graduate research studentships; 50,000*l.* to endow a new chair of chemical engineering; and 50,000*l.* for a chair of electronics. At present, the College has endowments which bring in an annual income of 19,000*l.*; and grants from local authorities, which amounted to 28,875*l.* in the year 1952-53, will be

* *University Development: Report on the Years* 1947 to 1952. Cmd. 8875. H.M. Stationery Office, York House, Kingsway, London, W.C.2. [Price 3*s.* 6*d.* net.]

34,450*l.* in the current year, as the Corporation of Newcastle-upon-Tyne have increased their contribution from 12,500*l.* to 20,000*l.* The University Grants Committee provided the capital sum for the erection of the new Stephenson Building, which was described in our 138th volume (1934), on page 267, *et seq.*; and some of the great industrial firms of the North-East Coast, together with a number of private donors, have responded already to the Rector's appeal to the extent of some 160,000*l.*

This is certainly gratifying; but it is to be hoped that the lesson of the impasse to which excessive taxation, coupled with rising costs, have brought this one of the many universities and colleges in the country will not be lost upon successive Chancellors of the Exchequer or upon the individual Members of Parliament, present and future, who collectively mould the policies of Governments. It is preferable in every way that universities should preserve that measure of financial independence which will best enable them to develop their own individualities instead of assuming the common level that is too apt to result from a predominance of central control—and all the portents indicate that centralised finance means an eventual centralisation of administrative policy also.

NOTES.

FLYING DISPLAY AT FARNBOROUGH.

NEXT Monday, September 7, the annual flying display and static exhibition of the Society of British Aircraft Constructors will open at Farnborough aerodrome, Hampshire, and will be held throughout the week. The last three days—Friday, September 11, to Sunday, September 13—will be open to the general public; during the other days, admission is by invitation only. Except on Thursday, when a special programme of civil aircraft only has been arranged, it is expected that aircraft appearing in the flying display for the first time will include the Handley Page Victor "crescent-wing" bomber aeroplane, on order for the Royal Air Force under super-priority; the Short and Harland S.B.5 variable-sweepback research aircraft; and the Short and Harland Sea Mew anti-submarine aircraft, which made its maiden flight recently and has been ordered in quantity for the Royal Navy. Rolls-Royce Avon RA14 reheat jet engines will be demonstrated for the first time in a Canberra flying "testbed"; the height-record Olympus Canberra flying testbed is also expected to appear. Developments of existing aircraft making their first appearance include the Blackburn and General Aircraft Beverley military freighter and troop-transport aeroplane; the de Havilland Series 2 Comet airliner, which is expected to fly over; the de Havilland Heron Mark 2 airliner with retractable undercarriage; the de Havilland Canada Beaver Mark 2 light transport aircraft, with an Alvis Leonides engine; the Bristol 173 Mark 2 twin-rotor helicopter, with stub wings; the Hawker Hunter Mark 2 powered by an Armstrong Siddeley Sapphire engine; and the Boulton Paul P.111A delta-wing research aircraft. There will be a formation flight by Avro delta-wing aircraft—the Avro Vulcan delta-wing bomber which flew for the first time last year, two 707A high-speed research aircraft, a 707B low-speed research aircraft, and a 707C dual-control aircraft. The Avon-powered Hawker Hunter and Vickers-Armstrongs Swift single-seat fighter aircraft will be flown with reheat this year. Among other aircraft flying are the remaining "super-priority" machines—the Fairey Gannet anti-submarine aircraft, the English Electric Canberra bomber and photographic reconnaissance aircraft, the Vickers-Armstrongs Valiant bomber aircraft, and the Gloster Javelin all-weather delta-wing fighter aircraft; and the Vickers Viscount and Bristol Britannia airliners. The dH110 twin-jet fighter aircraft, now under development for the Royal Navy, will also appear. The Saunders-Roe Princess flying boat is expected to make a six-minute flight on each day of the show. In addition to the Bristol 173 helicopter, three well-known helicopters will take part—the Westland S.51, the Bristol 171, and the Saunders-Roe Skeeter. Other familiar types to be seen are the Westland Wyvern naval strike fighter, now in service with the Royal Navy, the Avro Shackleton reconnaissance aircraft, the Percival Pembroke, the Hawker Sea Hawk naval fighter, the Gloster Meteor 7 trainer, the Percival Provost trainer, the Auster trainer, and the Prestwick Pioneer ambulance aircraft.

TECHNICAL COLLEGE ACCOMMODATION.

In their report on technical education published recently, the Select Committee on Estimates draw particular attention to the serious shortage of satisfactory accommodation, and conclude that "while these conditions persist, it will not be possible to ensure a full return for the money spent on technical education, and that the national effort is bound to be retarded." The report, the twelfth from the Select Committee on Estimates during the session 1952-53, is published by H.M. Stationery Office, price 7*s.* 6*d.* net. A considerable part of the report is concerned with the existing methods employed for examining proposed schemes for further building and for the policy adopted for authorising expenditure. The committee adversely criticise the system whereby technical colleges are built by instalments, a process which is described as being "expensive in money, labour and materials." A marked difference between England and Wales on the one hand, and Scotland on the other, is noted in the report. Notwithstanding the even greater shortage of accommodation in Scotland as compared with the former area, it is possible for the Scottish Office to meet all demands made by their local authorities, who have relegated building for technical schools to a secondary priority with respect to other education. In England and Wales, however, the position is completely reversed, technical education being regarded as the highest priority, and the demands for expenditure greatly exceeding the available funds. Special attention is drawn to the system of part-time day release for the further education of young people, a form of education supported by most employers and particularly favoured by the trade unions. In this respect, it is noted that whereas numbers attending evening classes are so great as to preclude further expansion in attendances, existing facilities will, in limited circumstances, permit the further development of part-time day release courses. Of particular interest is the evidence given of the value of further education for unskilled people, it being suggested that better discipline and a greater sense of responsibility have resulted from further education at all levels. Isolated instances of a lack of a suitable teacher are quoted as being the reason for not meeting a particular demand by a firm for an educational course, but no general discussion is recorded, or recommendations made, on the supply of lecturers and teachers for further technical education.

JUBILEE OF LETCHWORTH GARDEN CITY.

The 50th anniversary of the establishment of the first garden city in Great Britain, on a rural site at Letchworth in Hertfordshire, occurred on Tuesday, September 1. This establishment was based on the proposals made by the late Sir Ebenezer Howard in a book entitled *To-morrow: A Peaceful Path to Real Reform*; and the early struggles to translate what have been called his shrewd ideals into bricks and mortar (not to speak of the many other factors which go to make up a human community) are well set out in a special issue of *Town and Country Planning*, which is published at 28, King-street, London, W.C.2, at the price of 1*s.* 6*d.* The basic idea of a garden city, which is now receiving somewhat belated development in many parts of the country, may be described as the ordered planning of housing in proximity to healthy factories. At Letchworth, progress in this direction was at first slow, since the pioneers were faced with many difficulties of various kinds. At the present time, however, the area covered by the urban district is nearly 4,900 acres, while the population amounts to rather over 21,000. There are 5,818 houses and 227 flats, as well as 150 factories with an estimated floor space of 2·2 million sq. ft. The engineering industry is well represented, the products including water heaters, pyrometers, calorimeters, motor cycles, electrical fittings, printers' and mining machinery, precision tools and electric hoists. There are good educational and shopping facilities and the layout of the roads is attractive. Letchworth to-day is, in fact, a monument to the foresight of the few who recognised the virtues of the garden city principle and it provides many examples of sound town-planning, which may well be followed by those who are now engaged in similar developments. It is planned for an ultimate population of 32,000.

ADVANCED SHORT COURSES FOR INDUSTRIAL SCIENTISTS AND TECHNOLOGISTS.

It can perhaps be agreed that any major increase in productivity during the next five to ten years will largely depend on the efforts of those already employed in industry; and that, if this increase is to be obtained, it is essential that scientists and engineers should have every opportunity of keeping abreast of developments and of becoming aware of new techniques. With this end in view, 500 courses (40 of which were residential and involved full-time attendance) were provided in this country during the past year, the syllabuses being of post-graduate standard and of a highly specialised type in such subjects as electronics, structural analysis, steel-works lubrication, efficient heat utilisation and toothed gearing. In order to promote developments in this direction and to secure more publicity for the underlying principle, the Ministry of Education is asking Regional Advisory Councils or Academic Boards, in conjunction with Local Education Authorities, to make a special survey of the needs for these courses and to give advice on the provision required. A list of all full-time courses will be kept at the Ministry and details will be sent to the Federation of British Industries and the National Union of Manufacturers for the information of their constituent organisations. Firms and employing organisations generally, as well as individuals, are also being invited to make suggestions for courses to the secretary of the appropriate Regional Advisory Council. It is hoped in this way to make the need for courses, especially those of short duration, more apparent, and thus to increase the demand for them. In this connection, stress is laid on the suitability of part-time day and evening courses, since these could be conducted by lecturers from industry and would not cause so long a break in productive employment.

AIR TRANSPORT MOVEMENTS IN THE UNITED KINGDOM.

The monthly figures for July, published by the Ministry of Civil Aviation, on activity at United Kingdom and Channel Island aerodromes reveal the increasing importance of air travel as a means of transport. The most noteworthy trends are the rapid growth of the cross-channel car-ferry services and the greatly increased volume of traffic handled by provincial airports. Air transport movements at United Kingdom aerodromes in July, 1953, numbered 29,000, approximately 12 per cent. more than in July, 1952. The total of passengers handled was 531,000, 28 per cent. more than in July, 1952. Freight loaded and off-loaded amounted to 10,000 short tons, an increase of 127 per cent. on the corresponding month of the previous year, caused almost entirely by the increases in cross-channel car-ferry traffic. Freight and vehicles handled at Lympne increased from 1,500 to 5,500 short tons, and Southampton freight and ferry traffic rose from 200 short tons in July, 1952, to 1,140 short tons in July this year. Post Office mail set down and picked up during the month increased slightly from the previous year's figure to 1,100 short tons. London and Northolt airports together handled 246,000 passengers, over 20 per cent. more than in July, 1952. At London Airport there were 4,970 air transport movements (an increase of 24 per cent. over July, 1952) and 145,850 passengers were handled

(42 per cent. more than in July, 1952). Airports at which passenger traffic increased considerably over July, 1952, were Lympne, 20,000 (250 per cent. increase); Birmingham (Elmdon), 11,000 (60 per cent. increase); Southampton (Eastleigh), 14,000 (49 per cent. increase); Manchester (Ringway), 34,000 (30 per cent. increase); Glasgow (Renfrew), 31,000 (25 per cent. increase), and Isle of Man (Ronaldsway), 32,000 (28 per cent. increase).

BULK PETROL TERMINAL.

A bulk terminal for handling fuel oils and petrol from their Coryton Refinery has recently been completed at their Wandsworth works by the Vacuum Oil Company, Caxton House, Westminster. The company's products are brought up the River Thames by barge from Coryton to Wandsworth, where they are discharged at the rate of 850 gallons per minute. From the wharf side two 8-in. mains carry the fuel to the single underground storage tank of 650,000 gallons capacity. A 6-in. fall on the mains ensures that they are self-draining. The underground tank is divided into six compartments, four of 120,000 gallons and two of 85,000 gallons, so that different grades of fuel oil and petrol may be stored. The tank is a reinforced-concrete structure, 12 ft. deep, with 6 ft. thick walls and a 3 ft. thick raft floor. Standing-water level in the locality is about mid-depth on the tank and the massive construction is partially intended to overcome the floatation problem when the tank is empty. External waterproofing is achieved by bitumen sheeting. The loading area above the tank has been laid out so that eight road tank wagons can be loaded simultaneously. Submerged pumps draw off the product from a level about 18 in. above the floor of the tank, so allowing for the separation of sediment and of water seepage into the tank. The seepage is drawn off daily and, after passing through a separator, is discharged into the local sewers. The loading arms are of the spring-balance type and each is fitted with a 3-in. flowmeter which will enable the tankers to be filled at the rate of 250 gallons per minute. The flowmeters are said to be accurate to 0·01 per cent., or one gill in 300 gallons and their use eliminates the dip stick except for check purpose. Similarly, the road wagons are also fitted with a flowmeter for checking delivery at the customers' premises.

OBITUARY.

MR. W. O. FENWICK.

We regret to record the death of Mr. W. O. Fenwick, which occurred in the West Middlesex Hospital, Isleworth, on Saturday, August 29, at the age of 60. He had been a member of the editorial staff of our contemporary, the *Electrical Review*, for many years, and had latterly occupied the position of technical editor. Although he had not been in good health for some time, he was in attendance at his office the day before his death. He was well-known to a wide circle of electrical engineers and journalists, among whom his genial presence will be greatly missed.

William Oliver Fenwick was born in Cairo on May 27, 1893, and was educated in that city and in Alexandria. He obtained his technical training at the Faraday House Electrical Engineering College, London, where he obtained a diploma, and during the course he served for a year in the drawing office of Fielding and Platt, Limited, Gloucester and the Bristol Corporation Electricity Department where he afterwards became assistant mains engineer and assistant power station engineer. In 1917, he was appointed assistant plant engineer at the Ailsa Craig Shell Factory, a position he held until a year later he became assistant to Mr. A. H. Allen, who was then technical editor of the *Electrical Review*. He continued in this position under Mr. Allen's successor, Mr. C. O. Bretelle, and on the latter's retirement in 1948 was appointed technical editor, a position which, as we have said, he was holding at the time of his death. Mr. Fenwock was elected an associate member of the Institution of Electrical Engineers in 1918 and was transferred to the class of member in 1942.

THE BENDING OF SIMPLY-SUPPORTED RECTANGULAR PLATES.

By K. R. Peattie, B.Sc., A.M.I.C.E., and G. F. Day, B.Sc. (Eng.).

An article by Professor W. T. Marshall* which appeared in Engineering for September 22, 1950, showed how relaxation methods could be applied to the problem of determining the deflections and stresses in simply-supported rectangular plates. In the work described below, which was carried out in the Civil and Mechanical Engineering Departments of the University of Nottingham, and is published by permission of the authorities of that University, the deflections and strains produced in a simply-supported rectangular plate subjected to point loading have been measured and compared with the values of these quantities obtained from solutions of the general equation of flexure of a thin plate by relaxation as well as series methods.

The stresses and bending moments produced in a plate subjected to loading normal to the plane of the plate can be found, once the deflected form of the plate has been determined. The general equation for the elastic flexure of a thin plate subjected to loading applied normal to its plane is:

$$\frac{\partial^4 w}{\partial x^4} + 2\frac{\partial^4 w}{\partial x^2 \partial y^2} + \frac{\partial^4 w}{\partial y^4} = \frac{p}{N}, \quad . \quad (1)$$

where w = the deflection normal to the plane of the plate of a point (x, y); p = the intensity of loading at point (x, y); $N = \frac{m^2 E t^3}{12(m^2-1)}$; $m = \frac{1}{\text{Poisson's ratio}}$; E = Young's modulus; and t = the thickness of the plate.

The bending moments and stresses can be obtained from the following expressions:

$$M_x = -N\left(\frac{\partial^2 w}{\partial x^2} + \frac{1}{m}\frac{\partial^2 w}{\partial y^2}\right), \quad . \quad (2)$$

$$M_y = -N\left(\frac{1}{m}\frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial y^2}\right). \quad . \quad (3)$$

$$f_x = \frac{6M_x}{t^2}, \quad . \quad . \quad . \quad . \quad . \quad (4)$$

and

$$f_y = \frac{6M_y}{t^2}. \quad . \quad . \quad . \quad . \quad . \quad (5)$$

where M_x and M_y are the bending moments per unit width and f_x and f_y are the stresses in the x and y directions, respectively.

Consider a plate to be positioned with respect to the rectangular axes x and y, as shown in Fig. 1, opposite. The boundary conditions for this simply-supported rectangular plate are: $w = 0$ at all edges; $M_x = 0$ at edges $x = 0$ and $x = a$; and $M_y = 0$ at edges $y = 0$ and $y = b$.

It is convenient to substitute into equation (1) the expression

$$\frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial y^2} = -\frac{H}{N}, \quad . \quad . \quad (6)$$

so as to obtain

$$\frac{\partial^2 H}{\partial x^2} + \frac{\partial^2 H}{\partial y^2} = -p. \quad . \quad . \quad (7)$$

At the two shorter boundaries, $w = 0$, $M_x = 0$ and $\frac{\partial^2 w}{\partial y^2} = 0$, and hence it follows from equations (2) and (6) that $H = 0$.

A similar condition can be shown to exist at all boundaries, i.e., both H and w are zero. A solution to the problem may then be obtained by applying relaxation methods to each of the harmonic equations (6) and (7) in turn. In this way, the more tedious direct solution of equation (1) is avoided, but it should be noted that the method is limited to plates with simply-supported edges.

To obtain this solution, these differential equations are replaced by their finite-difference forms and a square grid of lines is superimposed on the domain of the problem, as shown in Fig. 2, opposite. The relaxation process ensures that, finally, the finite difference equation is satisfied for each node of the grid. The finite-difference form of equation (7) as applied to any node, such as 0 in Fig. 2, is

$$\frac{H_1 + H_2 + H_3 + H_4 - 4H_0}{h^2} = -p, \quad (8)$$

and the residual at this node is given by

$$R_0 = (H_1 + H_2 + H_3 + H_4 - 4H_0) + h^2 p \quad (9)$$

This residual is defined if the intensity of loading p is known. In the particular case of a point load P, applied at a node, the load is considered to act over a square of side h, as shown in Fig. 3, herewith, so that, for that node, $h^2 p = P$. Initially, the H values at all the nodes are assumed to be zero, so that all the residuals are zero except that at the point of application of the load. Any suitable round number value can be assumed for P; say, P'. The relaxation process is then carried out, using the harmonic operator shown in Fig. 4, herewith, to obtain the values of H corresponding to a load P'.

The equivalent finite-difference form of equation (6) is

$$(w_1 + w_2 + w_3 + w_4 - 4w_0) + h^2\frac{H}{N} = R_0 \quad (10)$$

If the w values are assumed to be zero at each node, equation (10) reduces to

$$R_0 = h^2\frac{H}{N}. \quad . \quad . \quad (11)$$

In the application of the relaxation process to equation (6), the w values at all the nodes are first assumed to be zero and the initial residual at each node is taken to be the corresponding value of H obtained from the previous relaxation process. The relaxation process is then applied as before and the residuals are reduced to zero or to some very small value. Let the value obtained at any node be w'. This value is not the true value of the deflection at that node, because, in the first relaxation, the load applied was not the true value P, but an assumed value P'; and in the second relaxation, the residuals at each node were taken as H, and not as $h^2\frac{H}{N}$, which is required by equation (11). Therefore, the true value of the deflection at any node is given by*

$$w = w' \times \frac{P}{P'} \times \frac{h^2}{N}. \quad . \quad . \quad (12)$$

The finite-difference approximations for the bending-moment equations (2) and (3) are:

$$M_x = \frac{P}{P'}\left\{(2w'_0 - w'_1 - w'_3) + \frac{1}{m}(2w'_0 - w'_2 - w'_4)\right\}, \quad . \quad . \quad (13)$$

and

$$M_y = \frac{P}{P'}\left\{\frac{1}{m}(2w'_0 - w'_1 - w'_3) + (2w'_0 - w'_2 - w'_4)\right\}. \quad . \quad . \quad (14)$$

The surface bending stresses are obtained from the bending moments by equations (4) and (5).

A series method of solving plate problems which is applicable to rectangular plates under single-point loading is given by Timoshenko.* If a simply-supported plate of the form shown in Fig. 1 is considered, the deflection of a point (x, y) may be represented by

$$w = \sum_{r=1}^{\infty}\sum_{s=1}^{\infty} A_{rs} \cdot \sin\frac{r\pi x}{a}\sin\frac{s\pi y}{b}, \quad (15)$$

* "The Application of Relaxation Methods to Freely-Supported Flat Slabs," by W. T. Marshall, Ph.D., A.M.I.C.E., Engineering, vol. 170, page 239 (1950).

* *Theory of Plates and Shells*, by S. Timoshenko, Chapters III to V, inclusive. McGraw-Hill Book Company.

BENDING OF SIMPLY-SUPPORTED RECTANGULAR PLATES.

Fig. 1.

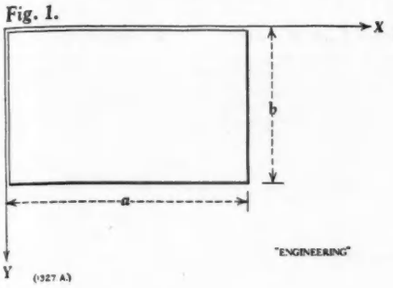


Fig. 2.

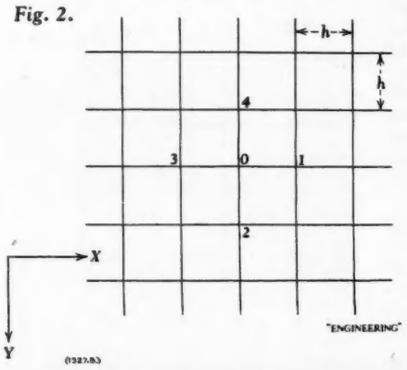


Fig. 3.

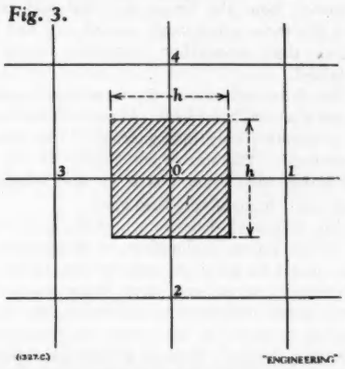
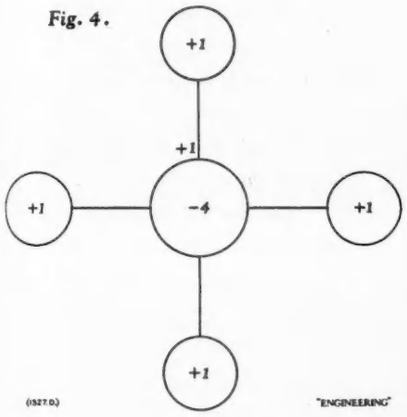


Fig. 4.



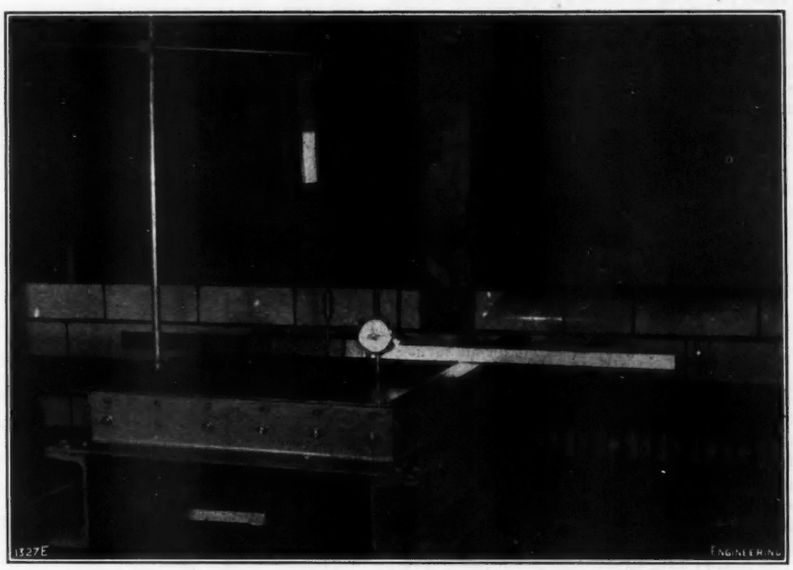
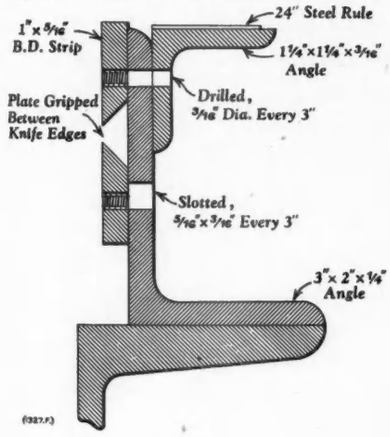


FIG. 5. GENERAL VIEW OF APPARATUS, SHOWING LOAD IN POSITION.

Fig. 6. TYPICAL EDGE SECTION.


1" × 5/16" B.D. Strip
24" Steel Rule
1¼" × 1¼" × 3/16" Angle
Plate Gripped Between Knife Edges
Drilled, 3/16" Dia. Every 3"
Slotted, 5/16" × 3/16" Every 3"
3" × 2" × ¼" Angle

where r and s are integers and A_{rs} is a coefficient. If P is a concentrated load applied the plate at (ϵ, η), by determining the strain energy in the point due to bending and by applying the principle of virtual work the deflection is given by:

$$w = \frac{4P}{\pi^4 a b N} \sum_{r=1}^{\infty} \sum_{s=1}^{\infty} \frac{\sin \frac{r\pi\varepsilon}{a} \sin \frac{s\pi\eta}{b}}{\left(\frac{r^2}{a^2} + \frac{s^2}{b^2}\right)^2} \cdot \sin \frac{r\pi x}{a} \cdot \sin \frac{s\pi y}{b}. \quad (16)$$

On substituting this expression into equations (2) and (3), the following expressions for the bending moments are obtained:

$$M_x = \frac{4P}{\pi^2 a b} \sum_{r=1}^{\infty} \sum_{s=1}^{\infty} \left(\frac{r^2}{a^2} + \frac{1}{m}\frac{s^2}{b^2}\right) \frac{\sin \frac{r\pi\varepsilon}{a} \sin \frac{s\pi\eta}{b}}{\left(\frac{r^2}{a^2} + \frac{s^2}{b^2}\right)^2} \sin \frac{r\pi x}{a} \sin \frac{s\pi y}{b} \quad (17)$$

$$M_y = \frac{4P}{\pi^2 a b} \sum_{r=1}^{\infty} \sum_{s=1}^{\infty} \left(\frac{1}{m}\frac{r^2}{a^2} + \frac{s^2}{b^2}\right) \frac{\sin \frac{r\pi\varepsilon}{a} \sin \frac{s\pi\eta}{b}}{\left(\frac{r^2}{a^2} + \frac{s^2}{b^2}\right)^2} \sin \frac{r\pi x}{a} \sin \frac{s\pi y}{b}. \quad (18)$$

On the substitution of specific values of a, b and m, etc., these expressions may be evaluated; but the evaluation for any number of points, except in the simplest cases of loading, is a lengthy process. The expression for the deflection at a point converges reasonably rapidly, and, consequently, this can be obtained sufficiently accurately by considering only a few terms of the series. The expressions for the bending moments, however, do not converge at all rapidly.

The apparatus used to measure the deflections and strains in a rectangular plate is shown in Fig. 5, above. The plate was supported between two 45-deg. knife-edge bearing strips, which gave line contact above and below the plate along each edge. The upper bearing strips were fixed in position and the lower strips were held through vertical slots in the side angles, so that the plate could be firmly gripped along its length. Details of the supports are given in Fig. 6, herewith.

The plate was of cold-rolled mild steel, its mean thickness being 0·0985 in., and the distances between the two pairs of knife edges were 24 in. and 16 in. The method of loading the plate can be seen in Fig. 5. A point load, resting on the plate, was partially suspended from a calibrated spring, so that the actual load applied to the plate could be determined. The magnitude of the load was determined to the nearest 0·1 lb.

Deflections of the plate were measured by a dial gauge, as shown in Fig. 5. Steel rules fixed to the dial-gauge carrier and along the long edges of the frame of the apparatus enabled dial-gauge positions to be easily determined. Deflection readings could be estimated to 0·0001 in., but some discrepancies occurred due to slight irregularities in the surface of the plate. Strains at various points on the plate surface were measured with Huggenberger tensometers, which were held in position by magnetic clamps. A gauge length of 1 in. was used for all strain measurements.

The plate was mounted in position and the lower knife edges were tapped up so as to bear on the plate. It was found that, with a central point load, the deflections were not symmetrically disposed about the longitudinal and transverse centre lines, and that it was desirable to use a zero load of some 5 lb. to ensure good contact between the plate and the lower supports. A central point load was applied and deflection readings were taken at some 20 points on the plate. The knife edges were tapped upwards at points where the lack of symmetry of the deflection readings indicated this to be desirable. After a series of seven such tests, a good condition of deflection symmetry existed, and the various deflection and strain measurements were then made. It is realised that the condition of deflection symmetry

does not guarantee that the edge conditions were, in fact, simply supported; but the plate was removed from the frame, reversed and replaced and the same adjustments carried out, and it was found that reasonably repetitive results were obtained.

The deflections and strains were first investigated under a central point load. Because of the two lines of symmetry, only one quarter of the plate was considered. The size of net chosen for the initial relaxation calculation was 4 in. and advances to 2-in. and 1-in. nets were then made.

The values of deflections and bending moments at various points on the plate, as obtained from the 2-in. and 1-in. grids are compared in Tables I and II, below. It is seen that there are comparatively small differences in deflections, but that the bending moments at the centre, show variations of over 20 per cent. Because of this large variation, a graded net, going down to a $\frac{1}{2}$-in. grid size round the load point, was used, as shown in Fig. 7, herewith. The results of this reduction in grid size are also shown in Tables I and II, and the variations are appreciably smaller except in the case of the central bending moment.

TABLE I.—*Deflections* ($\times 10^{-3}$P in.) *under Load Applied at Point* (12,8).

Point.	2 in. Grid.	1 in. Grid.	½ in. Grid.
(10,6)	1·247	1·228	1·223
(10,8)	1·400	1·366	1·358
(11,8)	—	1·464	1·461
(12,6)	1·359	1·326	1·318
(12,7)	—	1·453	1·441
(12,8)	1·573	1·518	1·500

A similar procedure was carried out for an asymetrical load applied at point (8, 4). Because of the lack of symmetry in this case, it was necessary to carry out the relaxation process over the whole plate. Solutions for 4-in. and 2-in. grids were obtained as described previously, but, as the amount of labour involved in advancing from a 2-in. grid to a 1-in. grid over the whole area of the plate would have been very large, a graded net was employed, in which a 1-in. grid was used within the area bounded by the lines $x = 0$, $y = 0$ and $x = 16$, $y = 8$. This grid is shown in Fig. 8, herewith; it will be seen that the fine net covers those parts of the plate which are subject to the greatest variation in bending moments.

The values of the deflections at a few points on the plate, under both central and off-centre point loads, were calculated by the series method, and a comparison between these results and those given by the relaxation solution are shown in Tables III and IV, herewith.

TABLE III.—*Deflections* (10^{-3} in.) *for* 1-*lb. Load at Point* (12,8).

Point.	Relaxation.	Series.
(6,4)	0·575	0·573
(6,8)	0·832	0·818
(12,2)	0·498	0·496
(12,4)	0·957	0·947
(12,6)	1·326	1·310
(12,8)	1·518	1·463

TABLE IV.—*Deflections* (10^{-3} in.) *for* 1-*lb. Load at Point* (8,4).

Point.	Relaxation.	Series.
(8,2)	0·510	0·506
(8,4)	0·902	0·859
(8,6)	0·955	0·949
(8,8)	0·861	0·850
(8,10)	0·688	0·680
(8,12)	0·475	0·472
(8,14)	0·242	0·239

As a preliminary to carrying out the measurements of deflections and strains in the plate under a central load. the deflections at six points in one quadrant were measured for increasing values of central load. It was found that, when the applied load exceeded about 20 lb., the load-deflection relationship at the points was no longer linear, and the loads used in the tests were kept below this value.

(To be continued.)

BENDING OF RECTANGULAR PLATES.

Fig. 7.

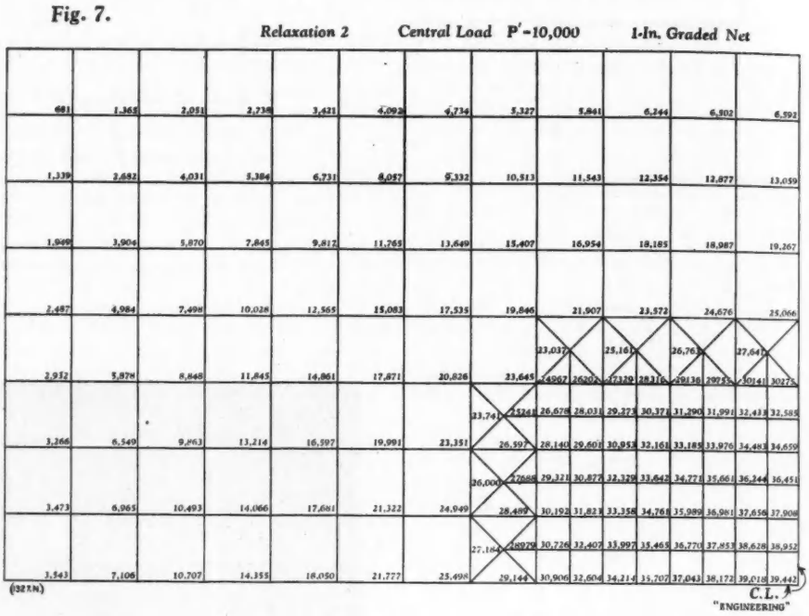


Fig. 8.

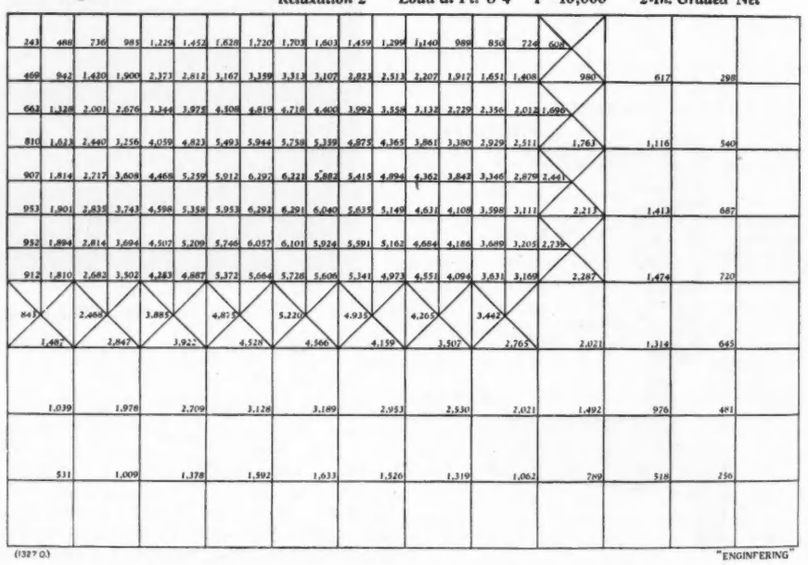


TABLE II.—BENDING MOMENTS (IN.-LB.) UNDER LOAD APPLIED AT POINT (12,8).

Point.	M_x			M_y		
	2-in. Grid.	1-in. Grid.	½-in. Grid.	2-in. Grid.	1-in. Grid.	½-in. Grid.
(10,6)	0·1049P	0·1079P	0·1084P	0·1409P	0·1437P	0·1444P
(10,8)	0·1176P	0·1160P	0·1172P	0·2175P	0·2153P	0·2112P
(11,8)	—	0·1864P	0·1847P	—	0·2890P	0·2869P
(12,6)	0·1782P	0·1763P	0·1724P	0·1527P	0·1511P	0·1524P
(12,7)	—	0·2505P	0·2480P	—	0·2237P	0·2216P
(12,8)	0·3073P	0·3782P	0·4488P	0·3457P	0·4165P	0·4868P

SINGLE-TRACK MECHANICAL BALLAST-CLEANING.—To obviate the necessity of occupying two tracks when using a ballast-cleaning machine (such machines usually discharge the dirt screened from the ballast into wagons on an adjoining track), a single-track method has been developed in the North Eastern Region of British Railways. The dirt, instead of being discharged sideways, is carried by conveyor belt over the rear of the machine to a hopper mounted on a gantry, fixed to the floor of an open-ended wagon and spanning its width. This wagon, and others coupled to it, are immediately behind, and on the same track as, the ballast-cleaning machine. The hopper is discharged into a normal motor dumper which travels up and down inside the line of wagons, the ends of which are lowered for the purpose, and loads them with the dirt received from the hopper. The speed of operation is stated to compare well with the older method of discharging into a train of wagons on an adjoining track.

PRESTRESSED FUSELAGE CONSTRUCTION.

AVIATION TRADERS (ENGINEERING) LTD., BISHOP'S STORTFORD.

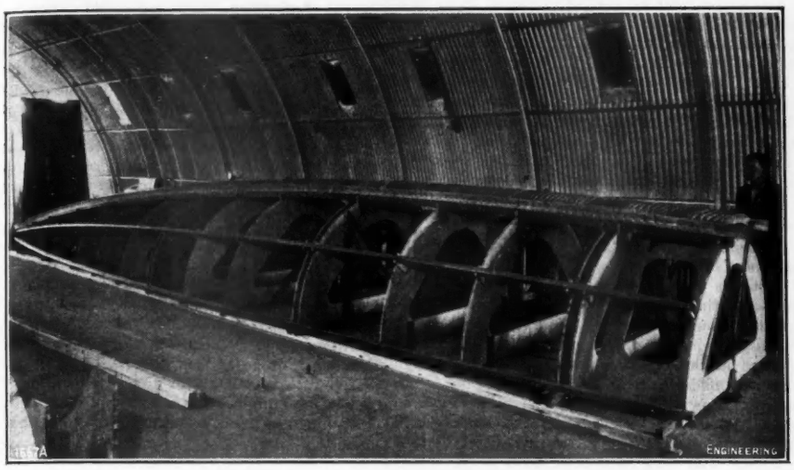


FIG. 1. METHOD OF FORMING PANEL.

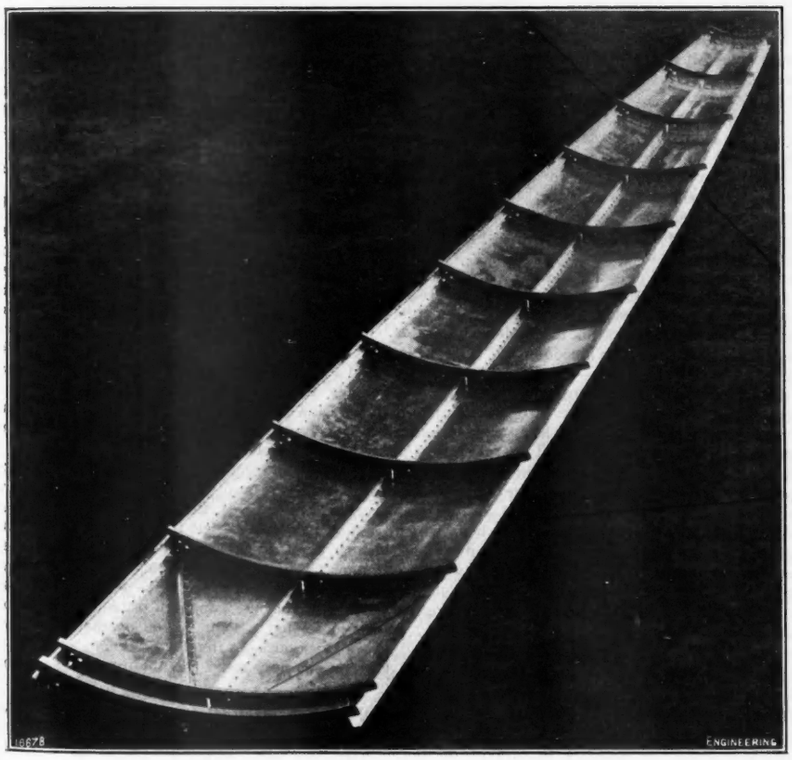


FIG. 2. COMPLETED FUSELAGE PANEL.

PRESTRESSED FUSELAGE CONSTRUCTION FOR AIRCRAFT.

AN interesting approach to the problem of simplifying and lightening aircraft structures is under investigation by Aviation Traders (Engineering) Limited, Stansted Airport, Bishop's Stortford, Essex, in the form of a fuselage shortly to be constructed on the tensioned-skin system invented by the company's chief designer, Mr. L. C. Heal. As noted on page 218, *ante*, the projected Accountant air-liner, intended as a DC3 replacement, is based on the new method of construction, as a result of which the designer expects an unusually high percentage payload and, on account of the remarkable simplicity of construction, a considerably reduced first cost. A prototype fuselage for the Accountant, to be used for structural tests, is now under construction at Stansted Airport.

The tensioned-skin method of construction has been developed in the first place for fuselages of circular cross-section, employing light-gauge material in which double curvature has to be introduced; it is thus particularly suited to medium-speed pressurised transport aircraft. The full extent of its possibilities for obtaining the required structural stiffness for high-speed combat aircraft cannot be determined until further testing experience has been gained. It is intended to develop the method for wing and tail unit construction also.

The method of construction is as follows. The fuselage is built up from an even number of identical longitudinal segmental skin panels forming a surface free from transverse skin joints. (Ten such panels, 42 ft. long, form the rear fuselage of the Accountant.) All the light-gauge skin panels are cut simultaneously, in the flat, against a master template, through which all common rivet holes are also drilled. Each panel is then stabilised by attaching light-gauge edge stiffeners—in the case of the Accountant, of beaded channel section with fluted webs. Since this operation is carried out in the flat, a straightforward run of machine riveting at a rate of some 40 to 50 rivets per minute is possible. Alternatively, spot-welding or metal-to-metal bonding techniques can be employed; the latter alternative has much to recommend it.

Fuselage "framelets" are then attached to the edge-stiffened panel, using the rivet holes already drilled in the sheet, and giving the entire panel the correct transverse curvature throughout its length. When the fuselage is completed, the framelets, bolted together, form complete circular frames. In the Accountant, the framelets are simple pierced and flanged channel sections formed from light-gauge aluminium-alloy strip; at each extremity the web is flanged for joining to the adjacent framelet through the abutting edge stiffeners. The ends of the panels are suitably stiffened by gusset plates. The skin panel has now taken up its transverse curvature, but has still to be formed to its longitudinal profile; in the case of the Accountant, this longitudinal curvature amounts to 0·18 in. in a length of 48 in. This operation is carried out very simply on a wooden jig, as illustrated in Fig. 1, on which the 100-sq. ft. panel is formed into double curvature by hand in about one minute. The wider end of the panel is located on the jig and secured by two tie-rods, forming a cantilever with the smaller extremity free above the jig. It requires a manual load only on the free end of the panel to bend it to conform with the jig surface; the free end is then tied to the jig. Fig. 2 illustrates a single completed panel of an early type; the central longitudinal stringer is eliminated in the Accountant panels. Although provision was made originally for tying down the panel to the jig at intermediate points along its length, it has, in fact, been found to be unnecessary. In bending the panel to shape, a tensile stress is introduced into the skin, attaining its maximum value of about 16,000 lb. per square inch on the longitudinal centre line, but reducing towards the edges where the stabilising effect of the edge stiffeners is felt, since the cross-section of the stiffened panel, or beam, is such that the neutral axis passes through or below the rivets attaching the skin to the edge members; the latter are in corresponding compression.

The residual tensile stress in the skin increases the stiffness of the panel appreciably and thereby, it is claimed, leads to a considerable weight saving, since the skin, being stabilised by tension, can be much thinner than is necessary in a conventional structure in order to avoid "waviness" arising from riveting and from aerodynamic loading and the effects of cabin differential pressure at altitude. Tests on an experimental Provost fuselage structure, carried out under a Ministry of Supply research contract in 1951, when the inventor was assistant designer at Percival Aircraft, Limited, showed that the new form of construction was some four to five times stiffer and stronger in both torsion and bending than a conventional structure using a heavier-gauge skin. Other advantages of the long-panel construction lie in the use of continuous double longitudinal members of constant section throughout, forming deep and strong assemblies; and, since all reinforcing for local attachments is on the inside of the shell, a smooth polished exterior surface is obtained.

As may be seen from Fig. 1, the jig is in the form of a half-fuselage. The completed panels are set up, and are secured together at about a dozen frame stations. Temporary end frames and ties are then secured to the skin half-fuselage before it is removed from the jig and placed on a cradle

which enables the panels to be attached to each other without difficulty. The floor structure can be added at this stage, or, alternatively, it can be inserted into the complete fuselage shell when the two halves have been assembled together. When the shell is complete, the doors and windows can be cut out after internal reinforcement has been added. Tests have shown that cut-outs so made have no adverse effects on the residual-stress distribution.

It is intended to use DTD610 aluminium-alloy strip for the Accountant fuselage skin. Since strip material for the continuous skins may be used in the "as-received" condition, no heat treatment is required as is the case with normal stretcher-press technique. Thus, in later applications of the method, it may be possible to use higher-grade materials which, combined with metal-bonding of the skin to the edge stiffeners, should result in a stiff, light structure of excellent appearance.

JUBILEE OF STEWARTS AND LLOYDS, LIMITED.

A FOUNDER of the firm now known as Stewarts and Lloyds, Limited, was Mr. Andrew Stewart (1832-1901), who in 1860 started a small plant called the Clyde Tube Works in St. Enoch's Wynd, Glasgow. Success attended his efforts and, at Coatbridge, a new and larger Clyde Tube Works was established in 1867. Five years before this, Mr. Stewart had taken his younger brother, James (1836-1886) into partnership, and a private limited company, Messrs. A. and J. Stewart, was established in 1882. Two years later the firm became A. and J. Stewart and Clydesdale, Limited, and in 1898, A. and J. Stewart and Menzies, Limited. Almost simultaneously with the Stewart enterprise, the manufacture of iron and steel tube was commenced independently in Birmingham in 1859 by Mr. Samuel Lloyd (1827-1918) and his cousin, Mr. E. R. Lloyd (1834-1896), trading as Lloyd and Lloyd, and in 1898 the firm was made into a private limited company. By 1903 the two firms were beginning to be acutely conscious of each other's presence, but, on taking stock of their relative positions, they found that their interests were complementary, not antagonistic, and amalgamation as Stewarts and Lloyds, Limited, took place on January 1, 1903.

To mark the jubilee of the amalgamation, a special number of the "S. & L. Review" has been prepared and issued by the firm at Brook House, Upper Brook-street, London, W.1. This, a handsome brochure of 160 pages, contains a brief history of the company and, as the chairman, Mr. A. G. Stewart, states in his foreword, gives "an illustrated commentary on the major events within the organisation, at home and overseas, that have occurred since Stewarts and Lloyds, Limited, came into being in 1903, and the national and international background against which they have taken place." Facsimiles of old letters, bills, posters, newspaper cuttings, and other documents make interesting reading, as do also lists of wage rates and escriptions of working conditions 50 years ago. There are many interesting photographs of groups of workpeople and the illustrations of workshops, machines and plant show the evolution of the works from their establishment to the present day.

The developments at Corby, where basic-Bessemer steel manufacture was commenced in 1935, include the winning of iron ore on a large scale and the provision of batteries of coke-ovens, blast furnaces, rolling mills and other plant, as well as a Bessemer-converter shop. Other developments in this country and in Australia, India, New Zealand and South Africa are dealt with. At the end of 1952, the firm, with its associates and subsidiary companies, employed over 37,000 persons in this country alone. Exact figures for the first year of amalgamation are not available, but it is considered to be doubtful if the employees in 1903 exceeded an eighth of this number. The 1952 output of steel tubes and fittings amounted to some 837,000 tons, compared with 85,000 tons produced in 1903.

LABOUR NOTES.

SEVERAL highly controversial subjects are likely to be brought up for discussion at the forthcoming annual meeting of the Trades Union Congress, which is due to be held at Douglas, Isle of Man, from Monday to Friday next week. One of the principal duties of the meeting will be to discuss the annual report of the governing body of the Congress, the T.U.C. General Council. This was published on August 25 and, as was to be expected, covers a wide field of industrial and economic subjects. Productivity, industrial efficiency, international competition, breakaway unions, and the effects of the 1953 Budget are among the matters referred to at some length.

In their introduction, the General Council record that there has been no basic change in the pattern of Britain's economic problems since the previous meeting of the Congress in September, 1952. There is still the same compelling need for the nation to pay its way in a world where the competition for overseas markets grows steadily fiercer and high industrial efficiency is essential for survival. The General Council report that they have taken an active part in the formation of the British Productivity Council and in all the activities of that body, and that they have tried to help the trade-union movement to shoulder its new responsibilities and fit itself for making constructive contributions to higher industrial efficiency.

Nevertheless, the General Council continue, they would have felt happier if the Government, on their part, had given some indication in the recent Budget that they were preparing to play a more positive and vigorous role in overcoming the difficulties facing the nation. In this connection, the General Council state that they pointed out to the Chancellor of the Exchequer in April last that the improvement in the balance of payments has been due largely to temporary factors such as cuts in imports and better trading terms, and not to the more controversial aspects of the Government's economic policy. Furthermore, trade unionists look upon the Acts passed to take the road-haulage and iron and steel industries out of public control as retrograde steps not calculated to improve the working of the nation's economy.

Regarding breakaway unions, the General Council state that they inquired fully into the complaint of the Fire Brigades Union at last year's meeting regarding the formation of a rival organisation, the Junior Fire Officers' Association. They found that, although a Conservative Member of Parliament was closely connected with the J.F.O.A., and that another had had some connection with a body which broke away from the National Union of Railwaymen, there was no evidence that such activities were inspired by the Conservative Party or that it was the policy of that Party to sponsor breakaway organisations.

Steps were taken by conciliation officers of the Ministry of Labour on August 26 to bring to an end the campaign of local stoppages organised by the Electrical Trades Union, at important building sites throughout the country, in support of their demands for increased wages. Although there was a continuation for the time being of the strikes already started, there was every indication, towards the end of last week, that the efforts of the Ministry would succeed. On Monday last, a meeting of the National Joint Industrial Council, comprising representatives of both sides of the electricity-supply industry, took place to discuss the union's claims. There was also a general resumption of work on that day. Unfortunately, the meeting, after lasting for some hours, ended in a deadlock. Electricians engaged on stands at Earl's Court for the Radio Show ceased work on the same evening. Strike action by men engaged on wiring stands at Olympia for the Engineering and Marine Exhibition, and by electricians employed at other centres throughout the country was resumed on Tuesday morning.

Equal pay for women employees in the Civil Service will not be introduced by the Government on a gradual basis until the methods by which this may be accomplished have been discussed with representatives on the staff side of the National Whitley Council. Mr. R. A. Butler, the Chancellor of the Exchequer, gave an undertaking to this effect in a letter sent by him to Sir Vincent Tewson, the general secretary of the Trades Union Congress on August 27. The Chancellor stated that he was as anxious as anyone that the matter should be handled by the established negotiating machinery.

Last year, the Chancellor explained in his letter, the Government had offered to open discussions with union representatives, but only on the understanding that the talks were to be exploratory and were not to commit the Government to taking any particular action. The staff side of the Whitley Council, however, had declined that offer. The position, as far as the Government were concerned, had not changed since. Any discussions which take place will be concerned solely with the arrangements for the gradual introduction of equal pay, in order that time may be saved when the Government decide that the new system may be begun. The Chancellor emphasised that it remained with the Government to decide when a beginning could be made.

Adult men employed in factories manufacturing glass containers are to have their wages increased by a penny an hour, or 3*s.* 9*d.* a week, according to the provisions of an award by the Industrial Court, which was published on August 27. The rates for women operatives will be advanced by ¾*d.* an hour, and the wages of juveniles increased in proportion. Previously to the award, a claim by the unions concerned for an increase of 3*d.* an hour for adults of both sexes had been presented to the employers and rejected. Some 25,000 men, women and juveniles employed in the industry are expected to benefit from the increases.

Breaks for breakfast at Admiralty dockyards are to be discontinued, according to an announcement by the Admiralty Industrial Council. Trade unions catering for industrial employees of the Admiralty have been informed that, in place of breaks for early-morning meals, it is proposed that working hours shall be adjusted, so as to commence at 7.30 a.m. instead of 7 a.m., thereby enabling workpeople to take their breakfasts at home. The concession of allowing a morning break of 15 minutes at Devonport, and 20 minutes at other dockyards and establishments under Admiralty control, was introduced during the war when long journeys were frequent and travelling arrangements were very difficult. With the growing need for economy in Navy Votes, it is felt that the loss of production, which the existing arrangement involves, can no longer be allowed. The new scheme will be introduced, the Council state, as soon as discussions with the various transport organisations involved are completed. Some 15,000 operatives at Devonport Dockyard are involved. There are signs that the unions may resist the abolition of their breaks.

Demands for an all-round wage increase of 3*s.* in the pound were presented on August 27 by the three principal railway unions to the Docks and Inland Waterways Executive, on behalf of the 22,000 persons in the Executive's employ. These demands were in line with those presented by the unions to the Railway Executive on August 7, on behalf of the 500,000 operating staff of British Railways. It is expected that the reply of the Railway Executive to the latter, the main claim in the series, will be delivered on September 15. On the same day, the Railway Executive are also expected to give their answer to the corresponding claim of the railway-workshop employees, in which some 135,000 railway shopmen are involved. A further claim in the series, also for an advance of 15 per cent. in wage rates, will be presented by the unions to the London Transport Executive on September 21, on behalf of railway operating staffs employed by that Executive.

PIPE BENDING AND FABRICATION SHOP.

FIG. 1. GENERAL VIEW OF SHOP.

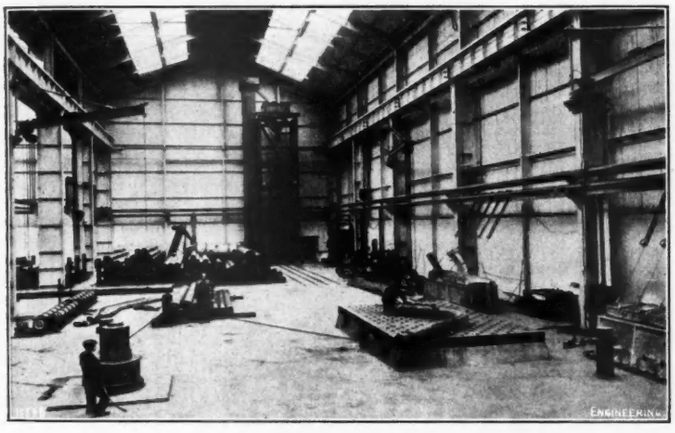


FIG. 2. PIPE-BENDING TABLE AND FURNACE.

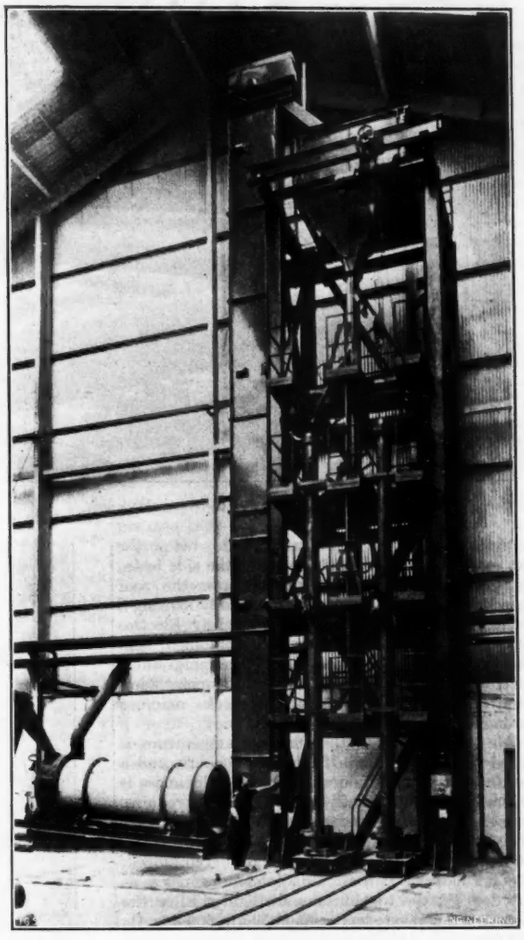


FIG. 3. ROTARY SAND DRYER AND FILLING TOWER.

PIPE BENDING AND FABRICATION SHOP.*

A REPORT which has been prepared by the Newcastle Division of the Northern Gas Board, in collaboration with C. A. Parsons and Company, Limited, Newcastle-upon-Tyne, describes the equipment of a new pipe-fabrication shop at Messrs. Parsons' works. Advantage was taken of a reconstruction at this works to erect a completely new shop to handle the fabrication of high-pressure and other pipe work for new power stations and similar installations. A general view of one end of the shop is shown in Fig. 1, on this page. The pipes range in type from mild steel to special chromium-molybdenum steels, and in size up to 12 in. bore with wall thicknesses up to 1¼ in. The shop contains a sand-drying and pipe-filling section, four pipe-bending units, and one Bonn cold-bending machine for pipes from 2 in. to 8 in. in diameter, a fabrication section and a heat-treatment and testing department.

SAND DRYING AND PIPE FILLING.

All sand employed for the filling of pipes prior to hot bending is first dried in a rotary drier, shown in Fig. 3, which was made by Foundry Equipment, Limited, Leighton Buzzard. This drier has a throughput of 3 tons per hour with a maximum gas consumption of 3,500 cub. ft. per hour through a simple air-blast burner. The filling tower, seen on the right of Fig. 3, was designed and built on the premises and is 45 ft. in height with four main filling platforms, and can handle two pipes at the same time. The sand, after drying, is raised by means of a bucket elevator to an overhead hopper of 3 to 4 tons capacity and is distributed by means of a number of chutes which are variable according to the length of the pipe to be filled. Electrical vibrators are fitted to ensure the tight packing of the sand, the ends of the pipe being sealed by plugs specially made for the purpose.

PIPE-BENDING HEARTHS AND PIPE FABRICATION.

Each of three large pipe-bending tables is served by two furnaces, as shown in Fig. 2. These furnaces, two each of 8 ft., 10 ft. and 12 ft. in length, are of simple open-ended construction, temporary end walls being built in to suit each particular job, while the furnace crowns consist of hinged 2-ft. sections, operated individually by compressed air. One such roof section can be seen raised in Fig. 2, to allow for the further heating of a pipe which already includes one right-angle bend. These furnaces were built by the Incandescent Heat Company, Limited, and are equipped with two Selas Type 118 louvred injectors per roof section. The burners are supplied with a 60 : 40 air-gas mixture and the gas ratings of the three sizes of furnaces are 2,500, 3,000 and 3,500 cub. ft. per hour. For high-pressure piping up to 4 in. bore and low-pressure piping up to 6 in. bore, two hearths of the type shown in Fig. 4, on page 314, are employed in conjunction with a small pipe-bending table. These were constructed by Messrs. Parsons and are fitted with Selas burners of similar type, the gas ratings of the furnaces being 1,500 and 2,000 cub. ft. per hour respectively. To enable local heating for particular applications to be carried out on the bending tables, a number of portable semi-circular furnace sections are employed. These are manufactured by Radiant Heating, Limited, and two types have been in use. The first incorporates two Premix mixing burners per section, firing tangentially to the pipe, one such unit being shown in operation in Fig. 5, on page 314, while the second type incorporates radiant multi-tunnel burners, also operating on the 60 : 40 air-gas mixture supply. For the production of crease bends semi-circular furnace sections of the multi-tunnel type are used, being some 9 in. to 5 in. in width.

Pipe cutting is carried out by oxy-town-gas Ferrolene burners, the rating of the Ferrolene plant being 650 cub. ft. per hour. Welding is carried out by the oxy-acetylene or electric-arc equipment depending upon the particular application.

STRESS RELIEVING AND NORMALISING FURNACE.

All fabricated pipe work and welding must be stress relieved, and normalising is necessary for all pipe work in chromium-molybdenum steel. The furnace employed for these purposes was constructed by the Incandescent Heat Company, Limited, and is shown in Fig. 6, on page 314. It is double-ended, with two bogies, and the internal dimensions are 28 ft. long, 12 ft. wide and 8 ft. high from the bogie top to the Laclede Christie suspended flat roof. Of the 42 burners, using gas at 3 in. water-gauge pressure and air at 18 in. water-gauge pressure, 28 fire between the transverse

* Report No. 526/52 of the Industrial Gas Development Committee of the Gas Council, 1, Grosvenor Place, London, S.W.1, from information supplied by the Northern Gas Board.

PIPE BENDING AND FABRICATION SHOP.

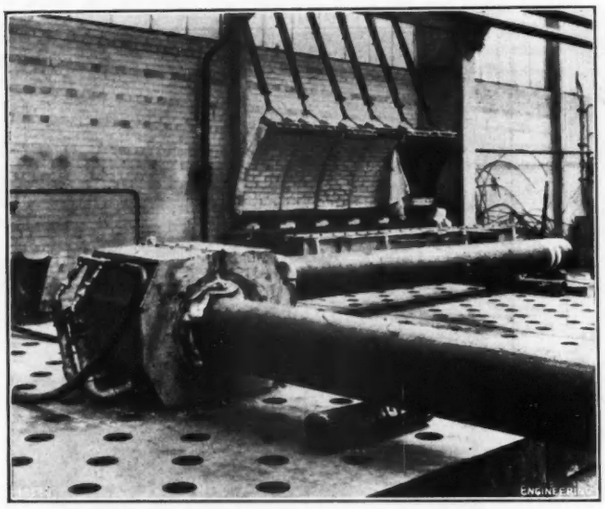


FIG. 4. PIPE-BENDING HEARTH.

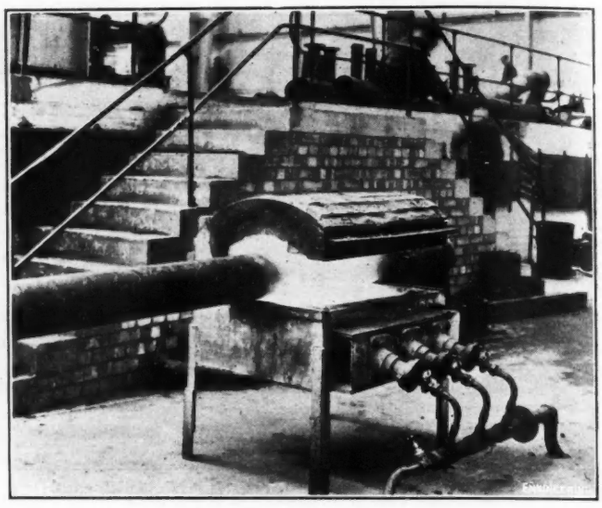


FIG. 5. PORTABLE LOCAL-HEATING FURNACE.

loading walls of the bogies and 14 fire below the flat roof. Flue uptakes, arranged in the side walls, lead into horizontal ducts built above the roof suspension steel work. A two-zone "fully-floating" temperature-control apparatus supplied by Electro-flo Meters Company, Limited, is combined with automatic furnace-pressure control. A programme controller is fitted, together with a 12-point temperature indicator to provide check readings throughout the chamber.

For stress relieving the furnace temperature is raised to 650 deg. C. in from 4 to 5 hours, and a soaking period of 2 hours per inch of thickness is generally allowed. The cooling schedule requires no fuel consumption since the cooling gradient of the furnace, with the damper closed, is only 20 deg. C. per hour, owing to the extensive insulation employed. For normalising chromium-molybdenum pipes at 950 deg. C., the top burners are lighted after the furnace temperature has reached 500 to 600 deg. C., and the cycle is completed in about 10 hours. The maximum gas rate is 22,500 cub. ft. per hour, of which the lower burners consume up to 15,000 cub. ft. per hour. No attempt has been made to determine the performance of this furnace since the hearth loading is light, owing to the varying shape of the pipe bends, and great care must be exercised in supporting awkward shapes to prevent distortion when normalising at 950 deg. C.

All completed pipe-work is tested hydraulically at the specified test pressure, which varies up to 3,000 lb. per square inch. In general, all welding work in pipes over 4 in. bore is tested by radiographic methods. The shop is served by a 12-in. gas supply which passes through two 20,000 B. and M. meters. Nearly half of the total gas used is passed through one of two Selas gas and air mixing and proportioning plants, providing a 60 : 40 air-gas mixture for the pipe-bending furnaces and miscellaneous torches. The remainder of the gas used is at normal district pressures. A low-pressure gas line and an air-gas water line have been arranged to run the full length of each bay to enable gas supplies of either type to be taken off at any point.

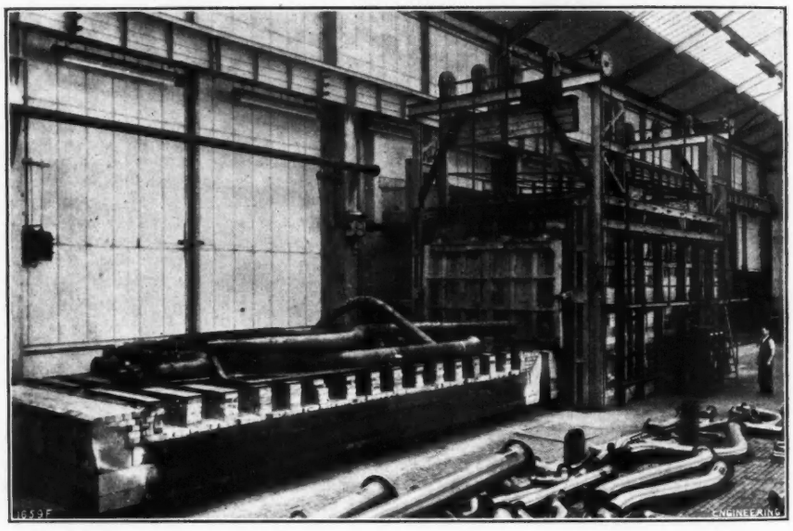


FIG. 6. STRESS-RELIEVING AND NORMALISING FURNACE.

NYLON DRIVING BELTS.—Lewis & Tylor, Ltd., 52, Grosvenor-gardens, London, S.W.1, have developed a driving belt with a cotton surface and nylon core. By suitable weaving, the nylon takes up the full tension of the drive while the cotton supplies the grip. The superior tensile strength of nylon enables a smaller belt to be made than one of cotton only, and the immunity of nylon from micro-biological attack avoids loss of strength from decay. As the nylon is in the core, and therefore near the neutral axis of bending, a very flexible belt is obtained. Moreover, owing to the special weaving, the stretch is less than in other fabric belts.

CONFERENCE ON HARDNESS TESTING OF STEEL.

THE Sheet and Strip Metal Users' Technical Association have arranged a conference and exhibition on the "Hardness Testing of Steel," to be held in the Memorial Hall, City Hall, Sheffield, from Wednesday, October 14, until Friday, October 16. The exhibition, which is being staged by hardness-testing equipment manufacturers, will be formally opened on October 14. The conference will be inaugurated at 9.30 a.m., on October 15, by the Master Cutler, Mr. R. L. Walsh. The contributions to be presented will include: "Hardness Testing with the Vickers Machine," by Mr. H. G. Harper, of Vickers-Armstrongs Limited; "Rockwell Hardness Testing of Sheet Material," by Mr. V. E. Lysaght, of the Wilson Mechanical Instrument Company; "Standard Indentation Tests," by Dr. K. Meyer, of the Institut für Harterei Technik, Bremen-Lesum, Germany; "Micro-Hardness Testing," by Mr. E. B. Bergsman, A.B. Svenska Metallverken, Vesteras, Sweden; "The Reichert Micro-Hardness Tester in Practice," by Dr. Onitsch, of the Shandon Scientific Company; "Reproducibility of Hardness Tests," by Mr. J. Woolman, of the Brown-Firth Research Laboratories; "Scratch Hardness Testing," by Mr. D. A. Oliver, of the B.S.A. Group Research Laboratory; "Practical Applications of the Double Cone Indenter," by Mr. P. Grodzinski, of Industrial Distributors (Sales) Limited; "Value of Hardness Testing as Inspection Procedure," by Dr. W. G. Shilling, of the Aeronautical Inspection Directorate, Harefield; and "Physical Meaning of Indentation Hardness," by Dr. D. Tabor, of the University of Cambridge. Further particulars regarding the conference and exhibition may be obtained from the honorary secretary of the Association, 49, Wellington-street, Strand, London, W.C.2.

AWARDS OF THE BRITISH INSTITUTION OF RADIO ENGINEERS.—The Council of the British Institution of Radio Engineers, 9, Bedford-square, London, W.C.1, have awarded the Clerk Maxwell Premium for 1952 to Dr. Charles Süsskind for his paper, "Obstacle-Type Artificial Dielectrics for Microwaves." Other awards in respect of 1952 include the Heinrich Hertz Premium to Mr. I. A. Harris, the Louis Sterling Premium for television technique to Dr. R. T. Theile and Mr. H. A. McGhee, the Brabazon Premium for a paper on aids to aircraft safety to Mr. P. L. Stride, the Marconi Premium to Mr. V. J. Cooper, and the Leslie McMichael Premium to Mr. J. A. Hutton. Awarded this year for the first time, the A. F. Bulgin Premium for a paper from a member of the Armed Forces has been conferred on Lieut.-Colonel J. P. A. Martindale. These awards and a number of examination prizes are to be presented at the Institution's annual meeting on Wednesday October 21.

SCIENCE FOR ITS OWN SAKE.*

By SIR EDWARD APPLETON, G.B.E., K.C.B., F.R.S.

THERE is, I think, something very appropriate in our meeting here in Liverpool, a city whose interests and history have been so long and so closely bound up with the advancement of science. This happy conjunction has been remarked on by several of my predecessors and has been a fruitful source of inspiration to them. I have noticed, on looking through their addresses, how often their thoughts have turned towards the practical achievements of science and how often they have been able to cite their instances from Liverpool itself. It is interesting to note, too, how the city has served, through successive meetings, to point the direction which science was to take.

To succeed to an office which has been held here in Liverpool by such men as Rutherford and Lister and Huxley can be no easy task. It is not only the abilities of these men which now appear so outstanding. What has particularly struck me, on reading their words, is the story of solid achievement each had to relate in speaking of recent scientific progress. "The heroic age of physical science" Rutherford appropriately calls the period that saw the first investigations of the radio-active elements, the discovery of X-rays and the development of wireless telegraphy; and again, speaking of the period between the two Liverpool Meetings of 1896 and 1923, he remarks "the epoch has been an age of experiment when the experimenter has been the pioneer in the attack on new problems. At the same time, it has also been an age of bold ideas in theory, as the Quantum Theory or the Theory of Relativity so well illustrate."

Joseph Lister, at an earlier meeting, dwelt in his address on the same conjunction of experiment and theory, and how their application in the field of medicine had led, in his own time, to the ever-memorable discoveries of anaesthetics and antiseptic surgery. A similar sense of substantial achievement is conveyed in the words of T. H. Huxley. Devoting himself to a theoretical account of the genesis of bacteria, he nevertheless pauses in it to estimate that the practical applications of the theory, in the French silk-worm industry and wine trade alone, had—to quote his own words—"repaired the money losses caused by the frightful and calamitous war of this autumn"—he was speaking in 1870. In Huxley's remarks, indeed, I seem to detect a certain diffidence about entering the realm of pure theory at all, for, after apologising to his audience for the dreariness of the theoretical approach to his subject, he continues: "Nevertheless you will have observed that, before we had travelled very far upon our road, there appeared, on the right hand and on the left, fields laden with a harvest of golden grain, immediately convertible into those things which the most sordidly practicle of men will admit to have value—namely, money and life."

What my predecessors had to tell was indeed a story of outstanding achievement; and yet what those great men had to say about the benefits of science can surely be equalled, if not surpassed, in our own day. It is true that nowadays we are more sharply aware of the debit, as well as the credit, side of our accounts with science, as my predecessor, Professor A. V. Hill, reminded us last year; but no one could doubt that the material benefits of science are there, and, indeed, are with us in our daily lives to an extent which even the Nineteenth Century could scarcely have expected.

Now the subject of my address, "Science for its own Sake," is already known to you. It was chosen to emphasise something that, at times, is in danger of being overlooked, namely, that science has interest as well as utility—that science is illuminating as well as fruitful. Having spent ten years of my own life in seeking to further the applications of science in the practical life of our country, I do not think I can be accused of under-estimating the vital importance of science as an instrument of material utility. I have long held the belief that the cost of scientific research is the price we must pay for our industrial progress; but we should be misleading the public, as well as ourselves, if we based our case for the general support of the pursuit of science on its utilitarian aspects alone.

I know that we can claim that many discoveries in pure science, which in their time had no obviously practical import, have later proved to be the foundations of major improvements in our material civilisation, but even that is an argument of profit and loss, and, to my mind, does not bring us entirely to the heart of the matter. I should like to go back, beyond the achievements, to the example of the scientist—be he amateur or professional—who is impelled solely by a passionate desire to explore and understand. That is what I mean by science for its own sake—when knowledge and insight are sufficient reward in themselves. Can the pursuit of a scientific vocation of this kind be a way of living worthily? Can it, in Dr. Johnson's phrase, help to advance us in the dignity of thinking beings? What values for us as individuals does it propound? As well as theoretical knowledge, as well as material benefit, is there some deeper, if more intangible, thing, even wisdom itself, to be found in our vocation?

I certainly make no claim to be able to provide the right, or the only, answers to such questions. At the most I simply hope to indicate to you where I think some of the value of a scientific vocation lies. After the extravagant claims that have sometimes been made on behalf of science—claims which have had the disagreeable consequence of putting the scientist on a pedestal—it is well that we should walk humbly. And yet, all the same, in a time of uncertainty of values and lowering of ideals, it is important that we should own to what we believe.

Now I begin by attempting to get the setting right, by pointing out that we scientists do not really inhabit the kind of universe which has sometimes been attributed to us. Science has so often been accused of having reduced the beauty and mystery of the universe to something cold and mechanical. When science enters the door, enchantment, it has been said, flies out of the window. You will remember the lines of the poet Keats:

"There was an awful rainbow once in heaven:
We know her woof, her texture; she is given
In the dull catalogue of common things."

Now it is fairly easy to see how this attitude came about. The world of what is now called classical physics, as it was mapped out for us from the time of Newton onwards, had the advantage of appearing comfortably solid and tangibly final. Anyone, it seemed, who could understand why an apple falls from a tree could also understand the stars in their courses. In this light the universe might well seem to a poet to fail to come up to his expectations. We now know how misleading it was to regard this account of the matter as final. Perhaps the most striking fact about modern science, in its explorations ranging from the heart of the atom to the frontiers of the universe, is that, like poetry, like philosophy, it reveals depths and mysteries beyond—and, this is important, quite different from—the ordinary matter-of-fact world we are used to. Science has given back to the universe, one might say, that quality of inexhaustible richness and unexpectedness and wonder which at one time it seemed to have taken away from it. "The world will never starve for want of wonders," said G. K. Chesterton, "but only for want of wonder."

I hope to try to illustrate all this in a moment from the fields of cosmical research which have been my own interest for many years; but just now one general point I want to emphasise is that the scientific approach to things is a far more personal and imaginative activity than is sometimes realised. I am ready to admit that deliberate application to discovery can often take us some distance; also that important progress can result from the operation of a team of workers, as distinct from an individual, though this is mostly the case when the follow-up or consolidation of a basic discovery is in question. But the big jumps ahead are usually the adventures and intuitions of a single mind.

I need hardly remind such an audience as this that scientific activities are twofold. We can make observations and experiments—that is to say, gather facts; and we can also seek to understand how the facts fit together. We express any order we can discern among the welter of facts in the form of a hypothesis or a theory. A theory, by the way, is only a hypothesis that has become, so to speak, respectable. Even then there is nothing final about it. As J. J. Thomson once said, a theory is a policy rather than a creed. Even in making observations, the scientific process is one which requires the fullest and subtlest employment of all our faculties. It demands, for example, that we should not only see things, but should notice them; and not only notice, but perceive them. Many a vital discovery has been nothing else than recognising the unexpected. To encounter Nature in this necessary state of awareness is inevitably to find all its forms and movements, from the infinitely small to the infinitely large, full of inexhaustible significance and relevance. But even in experimental work it is the primacy of an imaginative idea or intuition that often starts it all off. The important thing in experimenting is to ask Nature the right question and in its most direct form. Only then is the answer clear and unmistakable.

Many of our questions turn out to be wrong because they are unanswerable, but it is only by asking them at all that we eventually find we have asked the right one. And one knows how oddly, how unreasonably I might almost say, the right question has often flashed into men's minds. It was recorded by the German physicist, Helmholtz, that his best ideas only came to him when he was walking up a slowly ascending street—and, significantly enough, he was one of the founders of the principle of the conservation of energy! What I do know, from my own experience, is the fruitlessness of pondering over a scientific problem too long. The mind gets polarised and thought becomes captive to a groove. How often the best way of solving a scientific difficulty is to leave it alone! Also, speaking as a professional scientist who has only recently turned amateur, I would like to acknowledge the immeasurable debt which science owes to members of the latter category. My own subject of radio-physics has been advanced on many occasions by the observations of the gifted and enthusiastic amateur who was able to recognise the unexpected, even if his professional skill was insufficient to enable him to reveal its full meaning and implication.

Asking Nature the right question in the right way—or recognising a theoretical pattern in a tangled skein of experimental data—often has the effect of introducing an element of beauty and elegance into the scientist's work. Do we not, on occasion, refer to a "beautiful theory" and an "elegant experiment"? It is perhaps a little difficult to say what precisely we mean by this. Not, I think, that the theory or the experiment is necessarily conclusive or irrefutable, or even particularly fertile in its consequences—that would be virtue of another kind. The quality I have in mind is that of inevitability—and yet, paradoxically enough, an inevitability which can cause surprise. A great experiment seems to us, somehow, something which could not have been done differently; or, if it had, something essential would have been lost. We are surprised that someone thought of doing it that way, but we can see now that that way is really the only way to do it. In this respect a beautiful experiment can surely be classed with a great work of art.

I have spoken in general terms of the scientist's approach to Nature and of the kinds of mental quality and awareness that science requires in its followers; and I have tried to suggest that the exercise of these skills has a value in itself which is ample justification of a scientific vocation. To go farther might be claiming too much. And yet, I wonder. If we think of the great figures of science, and, to be fair, restrict ourselves only to those we have known intimately, can we not go farther and say that the scientific vocation, by its

* Presidential address to the British Association for the Advancement of Science, delivered in Liverpool on September 2, 1953. Abridged.

very nature, calls for personal qualities that deserve to be recognised and honoured? I might point, for instance, to that tolerance and open-mindedness to new ideas which shines even from the printed page of Rutherford's address to this Association when he was President here 30 years ago—that freedom from prejudice, muddle, hypocrisy and darkening of counsel which characterised the man many of us were so privileged to know.

Yet, in less serious vein, ought we not, as scientists, to try to see ourselves as others see us? Addison declared that there was this at least to be said for natural philosophy, that it occupied the attentions of men who, if they had pursued public affairs and politics with equal zeal and vigour, would have set the whole country aflame. Dr. David Hartley, in his *Observations on Man*, declared that "Nothing can easily exceed the vain-glory, self-conceit, arrogance, emulation, and envy that are to be found in eminent Professors of the Sciences, Mathematics, Natural Philosophy, and even Divinity itself. Temperance in these studies is, therefore, evidently required, both in order to check the rise of such ill passions, and to give room for the cultivation of other essential parts of our natures." And yet Adam Smith, in his *Theory of Moral Sentiments*, finds far more to say in our favour. "Mathematicians and Natural Philosophers," he says, "from their independency upon the public opinion, have little temptation to form themselves into factions and cabals, either for the support of their own reputation, or for the depression of that of their rivals. They are almost always men of the most amiable simplicity of manners, who live in good harmony with one another, are the friends of one another's reputation, enter into no intrigue in order to secure the public applause, but are pleased when their works are approved of, without being either much vexed or very angry when they are neglected. It is not always the same case with poets, or with those who value themselves upon what is valled fine writing." I only hope we scientists can see ourselves in that mirror.

For specific examples of what I have called the pursuit of science for its own sake there is, of course, no shortage of material on which to draw. I have decided, however, to tell you the story of only one field of development to-night. My story has been selected because it bears on what men think about the world rather than what they do about it, for it concerns the nature of certain objects in outer space whose nature has only been revealed in recent months.

From time immemorial, men have examined the sky with their eyes, and found it to be populated with luminous bodies, the stars shining with their own, and the planets with borrowed, light. As time went on, telescopes were used to assist the naked eye, and in this way it was possible to see more feeble and more distant stars. Generally, we may say that the bigger the telescope the more powerful it is in helping us to plumb farther into the depths of space. The 200-in. telescope at Mount Palomar can detect stars so far away that it takes the light from them 1,000 million years of travel to reach us. In such cases the human eye is supplemented by the photographic plate, which, through prolonged exposure, permits the photography of faint objects which can never be detected by the eye alone. In addition to the telescope, the astronomer has also looked at stars with a spectroscope, by which the light from the stars is analysed into its constituent colours. In this way it has been possible to identify the kinds of atoms which exist in stars; since we know, from experiments carried out on the Earth, how to recognise particular atoms by the particular colours or wavelengths of the light they give out.

It is of great interest to us here in Liverpool to-night to recall that it was Sir Oliver Lodge, one of the first professors in Liverpool University, who first thought of looking at the heavens with a "radio eye" instead of with an "optical eye." The year was 1900, in the earliest days of radio, and Sir Oliver tried to discover whether he could detect radio waves from our own particular star, the sun itself. The experiment failed because of the insensibility of the wireless receiver used—it was the day of the coherer; yet it would be no misnomer to call Sir Oliver the first radio-astronomer, for the experiment was surely conceived on right lines and, with modern valve equipment, would have commanded success.

However, it fell to an American radio-engineer, the late J. G. Jansky, of the Bell Telephone Laboratories, to discover that radio waves, as well as light waves, could be received from the heavens. One interesting feature of this discovery was that Jansky found all this out when he was looking for something else; but with impressive scientific awareness he was ready to recognise the unexpected. Jansky was primarily studying the direction of arrival of atmospherics, but he noticed a persisting hiss in his earphones when his directional aerial was aligned to received from a particular direction which he later showed was the direction of the stars in the Milky Way. The year was 1931.

Jansky, appropriately enough, was the first person to speculate on the origin of this radio noise from outer space. He pointed out that the most obvious explanation was that the radio waves came from the stars themselves and that we get the radio noise in strength from the Milky Way because a great population of stars is concentrated there. But when he came to test his hypothesis by looking for radio waves from our nearest star, the sun, he obtained a discouraging result; for, even with the equipment available in his day, he found, like Sir Oliver Lodge, that no radio waves were detectable.

It is one of the remarkable features of the history of this subject that Jansky's researches incited only a few sporadic observations in the way of repetition. During the second World War, however, radar operators, using their sensitive equipment operating on wavelengths of 5 to 10 metres, re-discovered the phenomenon; but that was a period when one had to distinguish sharply between the scientific things that were only interesting and the things that were really useful. A number of other matters of purely scientific interest arose in the same way, but all one could do was to note them and shelve them till the war was over.

I remember how these topics cropped up, during the war, in the discussions of a panel of young scientific workers of which I had the good fortune to serve as chairman. This panel was really a small sub-committee, though it had a long name* and a distinguished parentage. It used to claim that, unlike most other war-time committees, its membership was confined to scientific workers and did not include officials. That I might have been classed in the latter category was generously overlooked. The task of the Ultra Short Wave Panel was to examine and interpret all the manifold vagaries of radar transmissions which were reported to it from operational experience and from *ad hoc* experiments. The Panel had to concern itself with many things, including, for example, the profound influence of the weather on radio wave travel in the lower atmosphere. The foundation of a new subject, that of radio-meteorology, was one result of its labours. That was a matter of practical moment; but the odd bits of information on radio-astronomy, though choice delicacies for a scientific appetite, had to be renounced. I have in mind here, in addition to the detection of radio noise from the Milky Way, already mentioned, such subjects as the radar detection of meteors or "shooting stars" and the detection—for the first time—of radio waves of violent intensity coming out of sunspot regions on the face of the sun.

Soon after the war, however, these matters became the objects of further inquiry. Radar equipment, developed in the first instance for the detection of aircraft and ships, proved extremely useful for this purpose, requiring only minor adaptations. Dr. J. S. Hey and his colleagues, S. J. Parsons and J. W. Phillips, for instance, made the first really detailed investigation of the amount of radio noise coming from different parts of the sky. For this purpose, they converted a war-time radar receiver, which had been used in conjunction with anti-aircraft batteries, into a directional radio-telescope. Their work at once confirmed Jansky's original findings and showed that there was a close agreement between the intensity of the radio emission and the distribution of visible stars in the Milky Way.

Now I must digress from my main theme for a moment to remind you of a little of what is known about the distribution of stars in the universe as a whole. Our own solar system is really part of the Milky Way, which is itself a colony or island of stars in space. This island colony has a structure like a magnifying glass, circular in shape, but thicker at the centre than at the edges. We inhabitants of one of the planets in the solar system do not occupy, however, a particularly privileged position in it, for we are situated nearer to the edge of the island colony than to its centre.

Space is populated with far more stars than are to be found in our own Milky Way, but they are not distributed uniformly. They are grouped in island colonies exactly like our own. The astronomer calls these star colonies extragalactic nebulæ, and, with modern telescopes, it is possible to detect between 100 and 1,000 million of them. The average distance between any one of these star colonies or nebulæ and its nearest neighbour is about ten to a hundred times the size of either.

It was natural to assume at first that the radio noise coming from the sky represented the integrated radio effect of the stars in our own galaxy, since such stars are nearest to us. War-time experience concerning radio noise from the sun helped with the necessary calculations, for one could assume, as a first approximation, that all the stars would act like the sun. However, it turned out that there did not appear to be enough stars in the Milky Way to account for the high intensity of the radio noise. Then, as an alternative hypothesis, it was thought that possibly the noise came from the flying atoms and electrons which we know must populate the space between the stars. This was the inter-stellar matter theory. Unfortunately, here again there were found to be difficulties. To account for the high intensity of galactic radio noise, when observed on the longer radio wavelengths, required the ionised gas in inter-stellar space to be at a temperature of 100,000 deg., a value much too high to be reasonable. Also, we knew already that the inter-stellas material in question is concentrated in a narrow band near the galactic equator, quite unlike the wide dispersal of both the stars in the Milky Way and the radio noise. So another theory had to be abandoned.

We had therefore arrived at this position, that the cosmic radio noise could not be accounted for as coming from the visible stars in the Milky way or from the tenuous material existing in the spaces between the stars. However, this unpromising situation was soon relieved by an experimental discovery which, in its turn, led to others. Dr. J. S. Hey, observing the intensity of radiation from different parts of the sky, noticed that the strength of the radio noise from one particular direction—from a region in the constellation of Cygnus—occasionally showed rapid variations in a period of about a minute. At first it was thought that these fluctuations indicated variations in the emission from the source itself, but we now know that the variations are brought about by irregularities in the ionosphere, through which, of course, the radio waves must pass before they reach us on the surface of the earth. We can, in fact, look upon these variations as a kind of "twinkling" introduced by irregularities in the atmosphere. But the most startling conclusion which could be drawn from these observations was that the source of this variable radio noise must be a very small one. In the case of visual light, we all know that we can have a "twinkling" star—because the star is a small source—but not a "twinkling" moon.

Attempts were made immediately to find out, by even more refined radio experiments, how big—or how small—in size this radio source in the direction of Cygnus was. There is no time to describe the apparatus used, in Australia and in Cambridge, to test this matter, but both experiments qualify for my adjectives "beautiful" and "elegant." Both sets of investigators announced the same result, that the source in Cygnus was too small to have its

* The Ultra Short Wave Panel of the R.D.F. Applications Committee of the Advisory Council for Scientific Research and Technical Development of the Ministry of Supply.

size assessed with the equipment used—that is, that it occupied less of a tenth of a degree in the sky. However, in the course of the same experiments, the position of this powerful radio source was fixed pretty accurately. Maps of known stars were eagerly consulted to see if the Cygnus radio star, as we may now call it, coincided with any special visual emitter. The result of this examination was most significant, for it was found quite impossible to identify the radio source with any particular star. Within the region which contained the radio star many faint visual stars were found, but none seemed to exhibit any peculiarities likely to associate it with the very powerful intensity of the radio emission. Other parts of the sky were examined with the same apparatus and a further number of "point" sources of radio waves were identified. One was found, in the constellation of Cassiopeia, which was even more powerful than that in Cygnus. It also could be located with good accuracy; but here again there was no remarkable visible object apparent on the star map to connect it with.

Consider the effect of these observations on our outlook at the time. Could it be that a radio star is always a dark star—and so a new type of object in the universe? If so, could it be that there was a duplicate universe—only to be seen with a radio-telescope as distinct from a visual telescope? As regards the overall phenomenon itself, could it be that the total emission of radio waves from the galaxy might be really the integrated effect of these dark stars, just as the diffuse band of light of the Milky Way arises from the unresolved radiation from distant optical stars? The tendency of the time was still to think of the radio emitters as being neighbouring bodies and inhabitants of our own galaxy rather than of other, more distant, island colonies or nebulæ.

However, a little reflection will show that we must not rule out the possibility of radio nebulæ, as distinct from individual radio stars, even if we suppose that the greater part of our own radio noise comes from our own galaxy, the Milky Way. Any observer well outside the Milky Way should be able to detect the radio emission just as we, situated inside it, can do. Such an argument received strong experimental support when a group of radio-astronomers in Manchester noted a relatively faint, but quite detectable, emission from the Andromeda nebula, which is a neighbouring stellar island colony of our own. Further work, at Manchester and Cambridge, has revealed appreciable radio emission from other nebulæ not far from our own galaxy. It is clear that, in such cases, we are probably detecting their internally-generated radio noise from the outside.

But the problem of the much more powerful sources remained. Where were they, why were they so powerful, and were they, basically, radio stars or radio nebulæ? Again it was a case for more refined experiments which would enable their positions to be found with greater precision and give some notion of their sizes. Workers in Australia, under J. G. Bolton, had already tentatively identified one radio star with the Crab nebula, a diffuse expanding cloud of gas which represents the remains of a stellar explosion, visible news of which reached the earth, according to Chinese records, on July 4, 1054 A.D. So this was another radio source identifiable with a visible object, but it was of abnormal type, the ancient relic of a supernova eruption.

The real attack on the identification of the two major radio sources, those in Cassiopeia and Cygnus, depended on the more accurate identification of their positions. In 1951, some new determinations were made by F. G. Smith at Cambridge, and the results were communicated to the optical astronomers with an invitation to search afresh the parts of the sky in question. In the spring of 1952, a new and intensive optical search was therefore undertaken by Baade and Minkowski, at Mount Palomar, using the 200-in. Hale telescope and the 48-in. Schmidt telescope. As a result, two entirely unknown objects were discovered in the universe. The Cassiopeia radio source was found to be associated with a diffuse cloud of luminous gas, situated within our own galaxy, and possessed of unique characteristics. The tenuous matter of which it is composed is concentrated in a number of fine filaments which are in the most violent motion. From a study of the colour of the light emitted by different parts of the same filament it is concluded that the velocities of such movement are of the order of several thousand kilometres per second. The origin of this gaseous cloud is unknown, for it seems impossible to regard it as yet another supernova explosion.

The source in Cygnus which first gave the clue to the possibility of radio stars was found to be an entirely different type of object. Here the source of the radio waves was identified with another exceptional object which is considered to be two island colonies—two extra-galactic nebulæ—in collision. Moreover, the distance away of this compound group of stars is estimated as being such that it requires 100 million years for the light and the radio waves generated in it to travel to us here on the earth. Now when a collision of two nebulæ takes place it is considered that the stars of one island colony will pass freely between those of the other. On the other hand, the more extensive inter-stellar materials of the two island colonies will meet in collision, which will result in high excitation of the gaseous atoms of which this material is composed. One must suppose that, in both the radio source in Cassiopeia and the colliding nebulæ in Cygnus, the high gaseous velocities give rise to this intense radio emission, though the detailed mechanism by which it all comes about is not understood. These identifications were finally confirmed by observations in Manchester, Sydney and Cambridge, using still more refined methods of finding the sizes of these radio sources. The results of all three radio-observatories were gratifyingly consistent and were published simultaneously last December. In all cases it was found that the radio sources examined were definitely much bigger than simple stars, and corresponded to the sizes of the objects observed optically.

The accurate location of these radio sources in the universe has led, therefore, to new discoveries of great astronomical interest. Two unknown objects of unique character have been identified in the heavens, as a result of clues from the radio side; and it is to be expected that future accurate measurements of the positions of these cosmic radio emitters will lead, in turn, to the discovery of other visual objects of uncommon types. The radio-telescope has therefore shown itself to be an important adjunct to the world's largest optical telescope. In addition, there is another and a far-reaching possibility. It is the astronomer's idea to reach, with optical ranging, the hypothetical limit of the expanding universe, the distance where the extra-galactic nebulae are receding from us with the velocity of light. So far he has reached very approximately half-way; but the fact that, already, the second most intense radio source can be detected without difficulty at a distance equal to one-tenth of the maximum distance plumbed by the 200-in. telescope suggests that it may be possible, in time, to detect sources at greater distances by radio than by optical means.

In any case, the more detailed radio mapping of the radio sources in the heavens must go on, for we are still without an explicit solution of the original problem which started it all off, namely, the rough overall correlation of the distribution of radio noise with the general structure of the Milky Way. Much progress in these matters can be expected from the operation of two large British radio-telescopes. Professor A. C. B. Lovell's group is constructing a large steerable paraboloid 250 ft. in diameter, at Jodrell Bank, a station of the University of Manchester, which will be the largest single radio-telescope in the world and available for a great variety of investigations; and the large interferometric radio-telescope, recently completed at Cambridge, for work by M. Ryle and his associates, is already yielding entirely new results in the detailed mapping of radio sources.

The radio-astronomical story, therefore, is far from being fully told, but already one can record achievements in these three centres of Cambridge, Sydney and Manchester—partly in competition and partly in collaboration—worthy to be ranked with the greatest feats in the art of experiment.

I have tried to show how science, pursued for its own sake, can enlarge men's horizons and invest the world with deeper significance. As an exercise, we can claim it to be one of the most complex and far-ranging of our mental experiences. But there are other values and other experiences. At the opposite pole from our scientific endeavour there are the ways of thought which do not change, whose concern is with what is not new, with the things that will not be superseded; and to-day we stand in need of these enduring and sustaining values of the spirit more than ever. We well know that, in the field of science, our work will in due course be probably out-dated and certainly surpassed. At any one moment we may have only a precarious hold on a temporary truth, and our consciousness of this ever urges us to seek fresh truths and new understandings. I fear that, in doing so, we may lose sight of other aspects of life which have their values too; for there is a virtue in contentment, in being satisfied with what we already have, which we shall not learn from science.

Our vocation, in other words, cannot be the whole of life, for it cannot satisfy all our needs. Nevertheless, I hope I have represented it fairly as no unimportant or unworthy part of life. For we scientists are specially fortunate in this, that our vocation can never be simply an occupation; it is by its very nature, more than that—a dedication to an end. It often seems to me that what we lack in the world to-day is not so much the impulse to dedication as the opportunity for it. This, at least, the scientist need never lack; the opportunity is open to him everywhere "to strive, to seek, to find and not to yield."

We must still ask ourselves what it is that urges men to do these things, and our answer must surely be that it is the challenge of it all. Why should anyone want to climb Mount Everest? Simply, I suggest, because it is there—as a challenge of the unknown and the unaccomplished—a challenge to spirit and body, now so gloriously met by Hillary and Tensing. In its different setting, the pursuit of science also presents to the human mind an enduring challenge on an endless frontier, quite apart from the material enrichment of mankind to which it may incidentally give rise. "The work may be hard, the discipline severe," as Lord Rayleigh said on an occasion similar to this, nearly 70 years ago, "but the interest never fails, and great is the privilege of achievement."

WOLVERHAMPTON AND STAFFORDSHIRE TECHNICAL COLLEGE.—A prospectus of the full-time courses available at the Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton, for the session 1953-54 has been distributed by the Principal, Mr. C. L. Old. Students are prepared for the examinations for the London University degrees in science and engineering, for the associateship of the Royal Institute of Chemistry, for the College senior and advanced diplomas in civil, mechanical and electrical engineering, and for other examinations. An advanced diploma course in industrial engineering has been established to cater for the needs of specially selected students. The autumn term of the College is to begin on Monday, September 14.

FILMS AS A MEANS OF INCREASING EFFICIENCY AND PRODUCTIVITY IN INDUSTRY.—Five industrial sessions are being arranged in connection with the seventh annual congress of the International Scientific Film Association at the Royal Festival Hall, London, S.E.1, to which reference was made in our issue of June 5, 1953, page 706. At these sessions, demonstrations will be given showing the use of films for the purposes of industrial research, vocational guidance, work simplification, training, and welfare. Technicians from several European countries will show examples of the industrial use of films and take part in discussions on this subject. The sessions will comprise "High-Speed Films," on Tuesday, September 22, commencing at 10 a.m.; "Vocational Guidance Films," on Tuesday, September 22, at 2.30 p.m.; "Training Films," on Wednesday, September 23, at 2.30 p.m.; "Method Study Films," on Thursday, September 24, at 10 a.m.; and "Films on Industrial Welfare," on Friday, September 25, at 2.30 p.m. A certain number of representatives from British industry will be admitted to these sessions and persons desiring invitations should communicate with Mr. J. Stewart Cook, general secretary, Scientific Film Association, 164, Shaftesbury-avenue, London, W.C.2.

TRIPLE-PASS VERTICAL BOILER.

FRASER AND FRASER, LIMITED, Bromley-by-Bow, London, E.C.3, have recently introduced the "Fraser-Culmen" vertical water-tube boiler, in which, by a system of baffles, the hot gases are made to pass three times between the water tubes at an angle to their axis. An illustration of the boiler is shown in Fig. 1, herewith, and Fig. 2 is a vertical cross section. As will be seen, the rising hot gases are first deflected to the right by the lower dry baffle-plates, then horizontally (being contained by the upper dry baffle-plates) and finally escape upwards, between the upper ends of the water tubes. The dry baffle-plates are of cast-iron and rest on the wet baffles which form part of the inner shell of the boiler.

An advantage claimed for this particular design is that the convectional flow of the water is unidirectional over the heating surfaces from the point of intake until it leaves the stop valve in the form of steam, and that the deposition of scale is mainly confined to places from which it may be easily removed; also, as the grate is entirely surrounded by water, radiant heat is fully utilised. The boiler is made in eleven standard sizes, all to operate at 120 lb. per square inch, with grate areas of 9½ to 35¾ sq. ft., and with evaporations from 1,300 to 4,720 lb. an hour, respectively. The boiler diameters range from 4 ft. 3 in. to 7 ft. 6 in., the heights from 9 ft. 6 in. to 14 ft. 3 in., and the heating surfaces from 153 to 556 sq. ft.

Compared with the normal type of vertical boiler, a saving in fuel of 15 to 20 per cent. is claimed for the Fraser-Culmen design, and preliminary tests show an overall efficiency, under average working conditions, of 65 to 67 per cent. Steam can be raised from cold in 30 to 40 minutes. The design affords easy access to all parts, the tubes being particularly easy to clean through the large removable covers in the outer shell.

CONFERENCE ON WELDED STRUCTURES.

ARRANGEMENTS have been made to hold a conference for the consideration of outstanding problems relating to the design, fabrication and erection of welded-steel structures at the Institution of Civil Engineers, Great George-street, London, S.W.1, from Monday, November 23, to Thursday, November 26, 1953, inclusive. The organisation of the conference is being undertaken by a committee appointed jointly by the Ministry of Works, the Institution of Civil Engineers and the Institution of Structural Engineers, with the support of the Admiralty, War Office, Ministry of Supply, Ministry of Transport and the Department of Scientific and Industrial Research. Eleven papers have been selected for discussion, namely, "Design of Multi-Storey Framed Buildings," by Mr. W. A. Mitchell, "Problems of Fabrication and Erection of Multi-Storey Framed Buildings," by Mr. D. C. C. Dixon, "General Review of Welding in Shipbuilding," by Mr. F. C. Cocks, "Dock Gates and Caissons," by Mr. F. J. Walker and Mr. F. W. Sully, "Standing Oil Tanks and Gasholders," by Mr. M. Noone, "Design of Single-Storey Framed Buildings and Portal Frames," by Mr. W. S. Atkins, "Fabrication and Erection of Single-Storey Framed Buildings and Portal Frames," by Mr. R. W. Schofield, "Braced-Roof Structures," by Mr. S. M. Reisser, "Plate-Girder Bridges," by Mr. G. Roberts and Mr. O. A. Kerensky, "Trussed-Girder Bridges," by Mr. E. M. Lewis, and "Tubular Construction," by Mr. T. Bedford. The first session of the conference will be held on November 23, from 3 p.m. to 5.30 p.m., and on November 24, 25 and 26, there will be two sessions daily, from 10 a.m. to 1 p.m., and from 2.30 p.m. to 5.30 p.m., respectively. At each session, the author of the paper under discussion will briefly introduce his subject, after which the remainder of the time will be devoted to discussion. Copies of the papers will be issued in advance to those taking part in the conference and, at a later date, the papers will be published in book form as a permanent record of the proceedings. The conference will be open to all persons interested in welded structures, at a registration fee of 2*l.* 10*s.* Members will be entitled to take part in the meetings, and to receive an advance copy of each paper and one copy of the *Proceedings*. Applications for membership should be sent to the joint honorary secretaries, Conference on Welded Structures, at the Institution of Civil Engineers, not later than October 1, next. The conference is being sponsored by Lloyd's Register of Shipping, the British Welding Research Association, the British Constructional Steelwork Association, the British Iron and Steel Research Association, the Institutions of Civil, Mechanical, Electrical, Structural, Gas, and Municipal Engineers, the Institution of Naval Architects, and a number of other professional Institutions.

TRIPLE-PASS VERTICAL BOILER.

FRASER AND FRASER, LTD., LONDON.

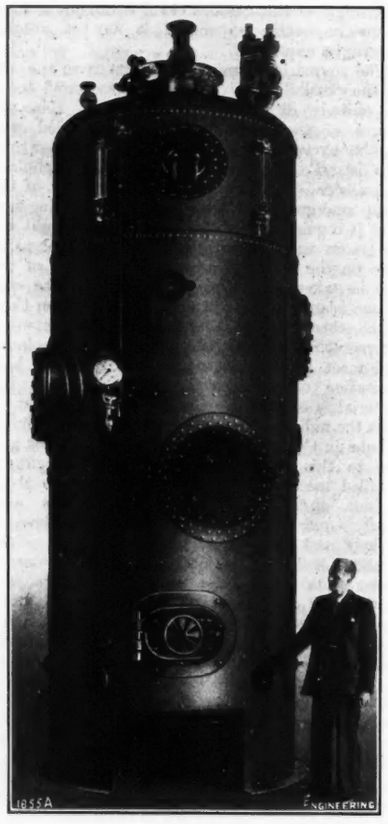
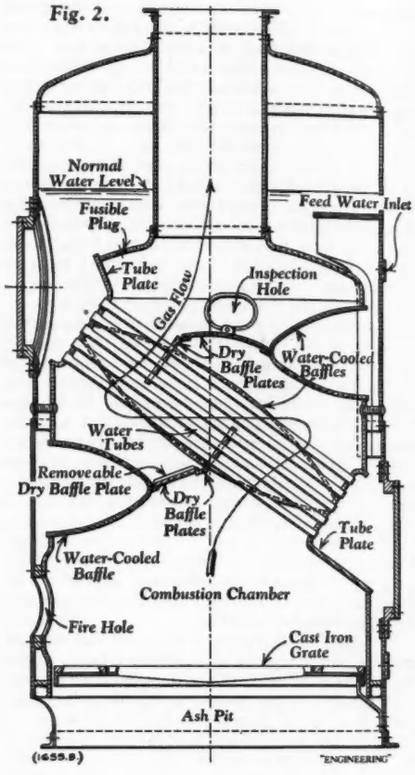


FIG. 1.

Fig. 2.



BRITISH MOTOR-VEHICLE PRODUCTION.—The production of all classes of motor vehicles in this country during the month of July reached the record figure of 52,844, which raised the total, for the first seven months of the year, to a figure 10,600 greater than the same period of 1950, the peak year of the British motor industry. Exports of cars totalled 32,000. The sharp rise in the export of cars is, to an extent, due to the easing of import restrictions in Australia, which received during July 3,000 more cars than during June. The total number of commercial vehicles exported was 11,400, the greatest number since May, 1952, and nearly 3,000 in excess of those exported in June. Exports of commercial vehicles to Australia and the Union of South Africa rose by 700 and 500 units; and increases of 250 and 90 vehicles sent to Belgium and Canada, respectively are also recorded. Among the vehicles exported were an extra 60 'buses and trolley-'buses which, together with an extra 1,300 trucks, added 1·7*l.* million to the total export value. In addition to these vehicle exports, 7,000 agricultural tractors were consigned to various parts of the world.

MODEL BY-LAWS FOR BUILDINGS.

THE Ministry of Housing and Local Government has just issued a new (1953) edition of *Model By-laws, Series IV—Buildings.** The new edition is substantially a reprint of that of 1952, compiled with the assistance of an advisory committee under the chairmanship of Mr. S. F. Wilkinson, C.B., of the Ministry. In the reprinting, clauses not generally adopted by local authorities have been removed from the main text and incorporated in an appendix; a few clauses, however, which local authorities have found useful, have been added. The opportunity has also been taken to refer to the new British Standard on "Fire Tests on Building Materials and Structures," in place of the standard published in 1932, and to insert the new Timber Economy Memorandum, which states that structural work of timber shall be deemed to be sufficient if "the design and construction are based upon the recommendations of British Standard Code of Practice CP 112, 'The Structural Use of Timber in Buildings,' or of Appendix A of the Ministry of Works Economy Memorandum No. 4, 'Use of Timber in all Building Work,' published by Her Majesty's Stationery Office in 1952." This 1953 edition covers 109 by-laws concerned with the siting, design and construction of buildings of different types and is primarily intended to assist local authorities to prepare and submit drafts of new by-laws which are due to be confirmed by December 31, 1953.

CARE OF BUILDERS' MACHINES.—The Ministry of Works has issued a leaflet (No. 33) of advice on the care and maintenance of builders' machines. The importance of cleanliness and proper lubrication, the regular changing of the oils in engines and gearboxes, and the need for a daily routine check for loose bolts is stressed, and the maintenance of concrete mixers, hoists, tractors and small excavators, etc., are also included. The leaflet is obtainable from H.M. Stationery Office, Kingsway, London, W.C.1, price 3*d.*

* H.M. Stationery Office, Kingsway, W.C.1. [Price 2*s.* 3*d.* net.]

PULSE-JET ENGINES FOR HELICOPTERS.

SAUNDERS-ROE, LTD., SOUTHAMPTON.

FIG. 1. 45-LB. THRUST UNIT.

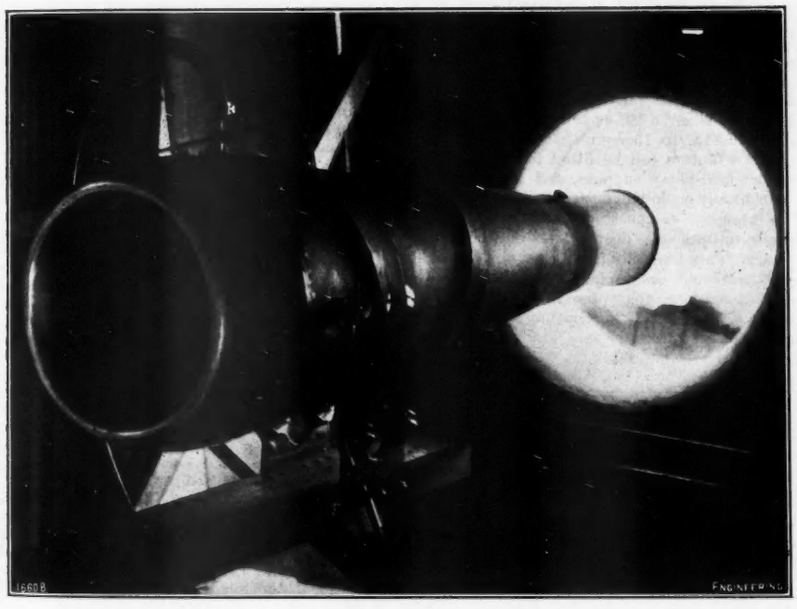


FIG. 2. 120-LB. THRUST UNIT.

PULSE-JET ENGINES FOR HELICOPTERS.

DURING the past year the Helicopter Division of Saunders-Roe Limited, The Airport, Eastleigh, Hampshire, have been carrying out experiments on pulse jet engines with a view to their application to blade-tip propulsion of helicopter rotors. There is a growing interest in reaction-driven rotors, as against mechanical drives, on account of the elimination of heavy complicated mechanical transmission and means for counteracting torque reaction; rotor-blade tip drives have already been successfully applied in America and in France. Simple pulse jet units, which require no mechanism within the fuselage other than a fuel pump and an air supply for starting, are particularly attractive for short-range military helicopters where noise is not of primary importance and where the saving in weight resulting from their use, in comparison with other forms of tip-jet propulsion, offsets the greater weight of fuel required. In addition to its possibilities for helicopter drives, the pulse jet has applications in the field of guided missiles, and as an assisted take-off unit for sail-planes. The Saunders-Roe company have recently released some details of a 45-lb. thrust pulse jet unit, illustrated in Fig. 1, which has now completed many hours of test running. It will be displayed in the static exhibition at the Society of British Aircraft Constructors flying display at Farnborough, to be held from September 7 to 13. It has an overall length of 47·5 in., a maximum diameter of 5·5 in., and a weight of 15·5 lb.; thus, it has a specific weight of 0·344 lb. per pound thrust. In Fig. 2 can be seen a larger 120-lb. thrust unit under development, which is now undergoing tests at Eastleigh.

The Saunders-Roe company describe the operation of a pulse-jet engine as being similar to a two-stroke internal-combustion engine, with the piston replaced by a column of air, and an automatic inlet valve at the combustion-chamber head. On starting, a mixture of fuel and air is injected into the combustion chamber and ignited by a spark. The resulting explosion forces the air column to the rear, thereby creating thrust and allowing the exhaust gases to escape from the chamber. The rapid ejection of the exhaust gases creates a depression in the chamber, inducing a fresh charge of air through the inlet valve into the chamber, where it is enriched with fuel. The "air piston" now returns, and in compressing the mixture it closes the inlet valve. Since the mean temperature of the mixture is high, spontaneous ignition occurs and the cycle repeats itself. The frequency of the cycle is determined by the acoustic properties of the combustion chamber; the 45-lb. thrust unit illustrated in Fig. 1 operates at 120 cycles per second.

NOTES ON NEW BOOKS.

Simplified Design of Roof Trusses for Architects and Builders.

By PROFESSOR H. PARKER, M.S. Second edition. John Wiley and Sons, Incorporated, New York. Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 32s. net.]

WHETHER the reader of this book will consider the designs to be "simplified" or not will depend on his own knowledge of the subject, but "detailed" would seem a more accurate description. The text is simple or, at least, elementary, in that it starts at the beginning with four chapters on graphic statics and the elements of strength of materials—but strictly limited to their applications in the design of roof trusses. In respect of the design of both steel and timber trusses, the book is complete and multitudinous examples cover most of the designs of roof trusses in these materials that a draughtsman is ever likely to encounter; but trusses are also made in light alloys and reinforced concrete. If, as the author appears to think, his readers will be able to deduce nothing from first principles for application to steel or to timber trusses, some mention should be made of the difficulties likely to be met when designing in alternative materials. Like many books from the United States, this volume suffers from giving too much detail on a restricted topic, while paying too little attention to the broader aspects of its subject.

Reviews of Research on Arid Zone Hydrology.

United Nations Educational, Scientific and Cultural Organization, 19, Avenue Kléber, Paris, 16. On sale by H.M. Stationery Office. [Price 25s.]

THIS volume contains a series of detailed reports, with maps and extensive bibliographies, on the main arid regions of the world. Individual sections deal with North-East Africa, the Union of South Africa and Angola, the Middle East, India and Pakistan, the United States and Canada, Latin America, and Australia. The reports were prepared by experts appointed by the Unesco Advisory Committee on Arid Zone Research, which was set up in 1951. The division of the arid areas of the world into the eight sections listed above was proposed by the Interim International Arid Zone Research Council, which was convened by Unesco at the end of 1950. The nature of the relation existing between the International Research Council and the Unesco Advisory Committee is not altogether clear, but credit for the work of assembling the valuable mass of information contained in this volume must go, apparently, to Unesco. The significance of arid zones in the overall economy of a country varies greatly in different cases. In Australia the extent of arid or semi-arid areas is so great that they constitute a major factor in any long-term views, or plans, envisaging ultimate development; in the United States, there are arid and semi-arid zones in the west, but local conditions enable artificial irrigation to be practised on a scale not likely to be reached in Australia. The whole question of insufficient rainfall and inadequate natural irrigation is probably of most immediate importance in countries faced with a food shortage, of which India is an example. The book does not deal with remedies; it is a collection of data which must form the essential basis on which any plans for amelioration or the development of dry lands should be based.

TRADE PUBLICATIONS.

Outdoor Oil Circuit-Breakers for Export.—Brush Export, Ltd., Loughborough, have sent us a pamphlet describing an outdoor oil circuit-breaker with a rupturing capacity of 1,000 MVA at 34·5 kV. The rating is quoted in accordance with American practice to meet American and Canadian requirements.

Electrostatic Precipitation.—Sturtevant Engineering Co., Ltd., Southern House, Cannon-street, London, E.C.4, have issued a revised edition of their illustrated brochure describing the principles and applications of electrostatic dust precipitation.

Permanent Magnets and Magnetic Materials.—Two interesting and informative booklets have recently been issued by Mullard, Ltd., Century House, Shaftesbury-avenue, London, W.C.2. One, entitled "Permanent Magnets," has been prepared for the use of engineers and designers requiring up-to-date technical information on modern permanent magnets, and includes comparative charts and data giving the characteristics of all types commercially available at the present time. These include the firm's Ticnal cast and sintered magnets, Magnadur ceramic magnets and Reco cast magnets. Reference is also made to the magnetic behaviour of commercial irons and steels normally used in conjunction with permanent-magnet alloys. The other booklet is devoted to Ferroxcube magnetic ferrites and gives an historical survey of magnetic ferrites, with details of their physical structure. The electrical, magnetic and mechanical properties of Ferroxcube are fully described and information on applications, standard core shapes and dimensions is also included.

Industrial Lighting Fittings.—A well-illustrated booklet received from Metropolitan-Vickers Electrical Co. Ltd., 1, St. Paul's Churchyard, London, E.C.4, gives details of their industrial lighting fittings.

Shaft Couplings.—The Renold and Coventry Chain Co., Ltd., Didsbury, Manchester, have issued a leaflet on couplings which they can supply from stock. These are the flexible-spider range of six couplings for horse-powers up to 20; flexible-disc couplings, in 16 sizes up to 600 h.p.; and chain couplings in 11 sizes up to 1,500 h.p.

Construction Engineering.—Foster Wheeler Ltd., Ixworth-place, London, S.W.3, have produced a booklet describing their capacity for the design and construction of engineering installations in the fields of steam generation, petroleum refining, chemical processing and large industrial plant.

Telegraph Distortion Measuring Set.—A pamphlet issued by Automatic Telephone and Electric Co., Ltd., Arundel-street, London, W.C.2, contains a description of a transmitter producing perfect telegraph signals of varying speeds into which predetermined amounts of distortion can be introduced. A receiver will measure the distortion of any teleprinter character, the speed of transmission and the neutrality, contact bounce and transit time of any teleprinter transmitting device.

Non-Destructive Testing Service.—A pamphlet giving details of their non-destructive testing service by X-ray, γ-ray, ultrasonic and eddy-current methods, as well as by ultrasonic penetrants, has been received from Solus-Schall, Ltd., 18, New Cavendish-street, London, W.1. Inspections can be carried out at the firm's testing stations at Bushey Heath, Hertfordshire, and Matlock, Derbyshire.

Lighting Fittings.—Messrs. Clarke, Chapman and Co. Ltd., Victoria Works, Gateshead, 8, have sent us a number of pamphlets describing fittings for fluorescent and tungsten lamps. Designs for use in mines and in dusty situations are included.

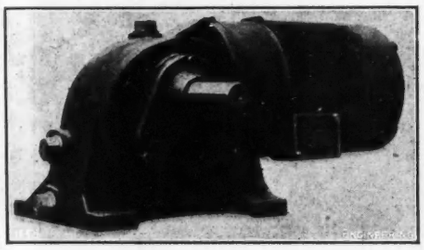
Pillar Drill.—A 1½-in. capacity pillar drill is described in a leaflet issued by Kerry's (Great Britain), Ltd., Warton-road, London, E.15. A flange-mounted 2-h.p. motor, driving through an infinitely-variable mechanism, gives spindle speeds from 55 to 1,440 r.p.m. An electric reverse is fitted for tapping operations. There is a hand-feed with a positive stop, and three power feeds with automatic releases. The work-table can be rotated, tilted or swung clear of the bed, allowing a working height of 43 in. The distance from spindle to column is 13 in.

Water-Tube Boilers.—Clarke, Chapman & Co., Ltd., Gateshead 8, Co. Durham, have issued a catalogue of their water-tube boilers and ancillary equipment. Illustrations and arrangement drawings are given of 20 boiler installations, with evaporation rates ranging from 6,000 to 550,000 lb. per hour. Crushers and stokers are also described.

Worm-Gear Reduction Units.—John Holroyd & Co., Ltd., Milnrow, Lancashire, have issued a brochure giving full particulars of their single-reduction worm-gear units. These have capacities of from 1 to 270 h.p. with ratios from 5 to 1 up to 70 to 1. Dimensions are given for the three types available: under-drive, over-drive and vertical drive. Double-reducton and lightweight models can also be obtained.

LOW-SPEED GEARED-MOTOR UNITS.

DOUBLE-REDUCTION geared-motor units, with output speeds ranging from 1·1 r.p.m. to 15 r.p.m., are now being made by Higgs Motors, Limited, Witton, Birmingham, 6. The accompanying illustration shows a complete unit. They are particularly suitable for driving conveyors, turn-tables, mixers, or other machines which need a low-speed input and a torque up to 100 lb.-ft., this being the capacity of the lower-speed models. They can be used also for remote-control devices. The motor can be supplied totally enclosed, for use in exposed places or dusty atmospheres; motor lubrication is only needed once in two years.



The speed reduction is obtained by a primary worm and secondary spur gears. The motor shaft is extended through the high-carbon steel worm and the end supported in a third bearing, housed in the gearbox. The wormwheel is of chill-cast phosphor-bronze and the spur gears of nickel-chromium steel. Six standard models are available, with output speeds ranging from 1·1 r.p.m. to 12·5 r.p.m. when a 50-cycle supply is used, or from 1·3 r.p.m. to 15 r.p.m. when the supply is 60 cycles. Motors can be fitted for either single-phase or three-phase supplies, and of either drip-proof or totally-enclosed construction.

The gearbox is constructed in one piece to minimise oil leakage; deep spigots and oil-flingers have also been fitted to make the unit oil-tight. Filling, level and drain plugs are provided. The overall dimensions are approximately 17 in. by 8½ in. by 7¾ in. high. The output shaft is $\frac{15}{16}$ in. diameter and projects 2½ in. The weight of the whole unit is less than 60 lb.

BOOKS RECEIVED.

Ohio State University Engineering Experiment Station. Circular No. 54. *Ohio Government and Conservation: Legislation, Program, and Administration.* By PROFESSOR FRANCIS R. AUMANN. The Director, Engineering Experiment Station, Ohio State University, Columbus, Ohio, U.S.A. [Price 50 cents.]

Water-Tube Boiler Defects and Repairs. By SYDNEY D. SCORER. John D. Troup, Limited, 90, High Holborn, London, W.C.1. [Price 12s., post free.]

United States National Bureau of Standards. Applied Mathematics Series No. 23. *Tables of Normal Probability Functions.* The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A. [Price 2.75 dols.]

Constructional Steelwork Shop Practice. By JOHN FARRELL. Published for the British Constructional Steelwork Association by Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.1. [Price 15s.]

Scientific Instrument Manufacturers Association of Great Britain, Limited. List of Preferred Valves. Offices of the Association, 20, Queen Anne-street, London, W.1. [Price 3s. 6d., post free.]

Water Supplies through Three Centuries. A Centenary Handbook to Commemorate One Hundred Years of Public Ownership of the County Borough of Preston Waterworks. By E. C. OAKES. The Waterworks Engineer, Municipal Building, Preston.

British Railways. Mechanical and Electrical Engineer's Department. Performance and Efficiency Tests. Southern Region $1C_2$-$C_2$1, 1,750-*h.p. Main-Line Diesel Electric Locomotive.* The Railway Executive, 222, Marylebone-road, London, N.W.1. [Price 10s. net.]

Der Industrielle Wärmeübergang für Praxis und Studium mit grundlegenden Zahlenbeispielen. By DR.-ING. ALFRED SCHACK. Verlag Stahleisen, Düsseldorf, Germany. [Price 38.50 D.M.]

BRITISH STANDARD SPECIFICATIONS.

THE following publications of engineering interest have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 2, Park-street, London, W.1, at the price quoted at the end of each paragraph.

Electric Cables and Flexible Cords.—Four publications relating to cables and flexible cords for electric power and lighting have been issued. They are B.S. No. 7, a seventh revision of a specification covering rubber-insulated cables and cords, first published in August, 1904; Amendment No. 2 to B.S. No. 883: 1949, relating to cables and cords for the electrical equipment of ships; B.S. No. 2004, a new specification concerning polyvinyl-chloride insulated cables and cords; and B.S. No. 2008, another new specification, covering vulcanised-rubber-insulated wire-armoured cables for collieries.

The new edition of B.S. No. 7 supersedes the previous, 1946, issue, and it incorporates many of the requirements of Government Department Electrical Specifications (G.D.E.S.) Nos. 1, 8, 9 and 10, which, it is understood, are being withdrawn. The supplement to the 1946 edition, which permitted polyvinyl chloride (P.V.C.) as an alternative to vulcanised rubber, is superseded by the issue of the new specification, B.S. No. 2004. The main changes in the revision of B.S. No. 7 are the reduction of insulation thickness and the introduction of quality clauses. [Price of B.S. No. 7, 10s., postage included.]

Amendment No. 2 to B.S. No. 883: 1949, which relates to cables and flexible cords for the electrical equipment of ships (including electric propulsion), brings Specification No. 883 into line with B.S. No. 7: 1953, as regards insulation and sheath thickness for vulcanised-rubber insulated cables. It also introduces a range of 250-volt mineral-insulated copper-sheathed cables, having up to seven cores, similar to the 660-volt cables already included. Tables of overall diameters with tolerances are also specified. [Price of Amendment No. 2 (reference P.D. 1665), 3s., postage included.]

As stated above, the new specification, B.S. No. 2004, replaces the supplement to B.S. No. 7: 1946, which permitted the use of P.V.C. as an alternative to vulcanised rubber for the insulation or the sheath, or both, for flexible cords and for 250-volt and 660-volt cables up to 0·06 sq. in. in cross-section. It deals only, however, with P.V.C.-insulated cables and flexible cords (sheathed or unsheathed) for working voltages up to 250 volts. The insulation thicknesses are similar to those for corresponding cables and cords specified in B.S. No. 7 and the physical tests for the sheath and the insulation are based on the methods specified in B.S. No. 7. [Price 6s., postage included.]

Specification B.S. No. 2008, which covers wire armoured cables for collieries, deals with twin-core and three-core 250-volt colliery lighting cables (other than for coal-face lighting) as well as 660-volt and 3,300-volt shaft and roadway cable. The insulation thicknesses are identical with the corresponding cores in B.S. No. 7. Dimensions are specified for each size of cable with single-wire or double-wire armouring, and taped and braided or served overall with hessian tape. [Price 5s., postage included.]

Cotter Slots and Quick-Release Tapers.—Two further publications in the series issued under the general designation, B.S. No. 1660: "Machine Tapers" have now become available. The first publication in the series, Part 1, related to self-holding tapers and gauges for self-holding tapers, and was issued in 1950. Of the two new publications, Part 2 is concerned with cotter slots and gauges for cotter slots and Part 3, with quick-release tapers and gauges for quick-release tapers. In Part 2, the dimensions of cotter slots intended for use with the tanged Morse-taper shanks and sockets standardised in Part 1 are specified. Details of the gauges for the verification of the slots are also given. In Part 3, the dimensions specified are based on those for the most commonly used American steep tapers, as employed on spindle noses and arbors for milling machines. Basic dimensions are specified for tapers designated Nos. 30, 40, 50 and 60, and the essential dimensions of spindle noses and arbors incorporating these tapers are given. As heretofore, provisions for suitable gauges are included. [Price 4s. each Part, postage included.]

NORTHAMPTON POLYTECHNIC, LONDON.—A prospectus of part-time courses in pure and applied chemistry has been issued by the Department of Applied Chemistry, Northampton Polytechnic, St. John-street, London, E.C.1. Students are prepared for the examinations for National Certificates and the professional institutions, including the Royal Institute of Chemistry and the Institution of Metallurgists. Other courses are devoted to corrosion science, fuel technology, metal finishing and chemical engineering. The session is due to begin on Monday, September 28.